REVISED 12/2008

Certification Training Manual

Including:

- **Refrigerant Recycling and Service Procedures for Mobile Air Conditioning Technicians**
- **Best Service Practices**

Approved by the U.S. EPA for technician training requirements under Section 609 of the Clean Air Act

This program is not intended to gauge the technical skills of technicians regarding the diagnosis and repair of motor vehicle air conditioners. The basic goal of the technician training and certification program is to teach technicians how to properly recover and recycle refrigerant, and why it must be done to protect the stratospheric ozone layer. In addition, the program provides information for servicing air conditioning systems with non-ozone-depleting alternate refrigerant.

SEE INSTRUCTIONS FOR TAKING TEST AND OTHER INFORMATION ON INSIDE FRONT COVER...

Important Notes!

- Do not mix up tests or exchange tests with other individuals at your place of business. All tests are coded with names matching assigned numbers.
- Please review your test upon completion. Any questions marked with more than one answer will be scored as incorrect. Any question not marked will be scored as incorrect.
- Completely fill in the block (■) to the left of the correct answer.
- Do **NOT** mark with a check (✔) or an "x" (✗).

General Information and Instructions

You have registered for MACS certification in REFRIGERANT RECYCLING & SERVICE PROCEDURES FOR MOBILE AIR CONDITIONING TECHNICIANS. Following are the steps* necessary for you to complete the prescribed training:

*** The following instructions apply to those technicians taking the MACS training course by mail. Those participating in a classroom program should follow the instructions of their trainer/proctor. Tests given in a classroom setting must be closed-book tests. The required score for passing these closed-book tests is less than that required for passing the open-book test.**

1. **Read the instruction manual that came with your recovery/recycling service equipment (and review the training video, if provided). Then read this manual cover to cover.** Re-read as necessary to gain full comprehension of the material presented.
2. **Take the enclosed test.** The test is an untimed, "open-book" test, so you may refer to the training manual as often as necessary to research answers to the questions posed. (Note, however, that you must correctly answer a minimum of 21 of the 25 questions to earn certification.) **You must complete the test by yourself, without assistance from anyone, and submit it for scoring. (See 4 below.)**
3. **Fill out and sign** the "Identification and Statement of Testing Conditions" block on the back of your test.
   Note: A reprint charge will be incurred if information provided is not legible.
4. **Mail your test** in the postage paid, addressed envelope provided to: **MACS-EIF, P.O. Box 88, Lansdale, PA 19446.**
5. ***MACS-EIF will advise MACS of your test results.***
6. ***MACS will advise you of your score and, providing that you have attained a passing score, will issue a certificate and a wallet-sized I.D. card, indicating that you have successfully completed this MACS certification training program.***
7. ***Persons not attaining a passing score on the first test will receive one retest at no additional charge. If the test was originally ordered via phone, fax or mail, the second test will be sent via U.S. mail. If the original test was ordered online, the second test will also be online. If a passing score is not attained on the second test, the process begins again with a new test purchase.***

Enclosed:

- Test with identification material and declaration to be mailed to scoring facility.
- Postage paid return envelope (MACS-EIF).

Important - Please note: Tests must be returned for scoring within 90 days of the date they are issued. MACS assumes no responsibility for tests submitted for scoring after this 90-day period. MACS will charge an additional fee for re-issuing tests which are lost, misplaced or destroyed.

Note: The MACS Worldwide office is open from 8:30 a.m. until 5:00 p.m. Eastern Time.

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Foreword

There is worldwide consensus that chlorofluorocarbons (such as the CFC-12 used as a refrigerant in mobile air conditioning systems) destroy the stratospheric ozone layer. This industry has moved with all possible speed to implement refrigerant containment and recycling of refrigerants in automotive air conditioning systems, and to develop systems that use a non-ozone-depleting refrigerant – HFC-134a.

Now it's all up to you!

If you fail to operate and maintain your refrigerant recovery/recycling service equipment as required by federal law, and as recommended by the equipment manufacturer, the development of recycling technology to reduce the release of refrigerant to the atmosphere will have been in vain.

You are key to the success of the national refrigerant recovery/recycling program, and a lot is riding on the success of the technology. Please take the time to read this manual completely and do your part to make the recovery/recycling program work.

A Note on Refrigerant Terminology

This manual makes repeated reference to two refrigerants: CFC-12 and HFC-134a.

- **CFC-12** (also known as R12) is a chlorofluorocarbon, and is composed of the elements chlorine, fluorine and carbon. Its actual nomenclature is dichlorodifluoromethane.
- **HFC-134a** (also known as R134a) is a hydrofluorocarbon, and is composed of the elements hydrogen, fluorine and carbon. Its actual nomenclature is 1, 1, 1, 2-tetrafluoroethane.

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**** See page 51 for information on how to purchase Standards from SAE International.***

Guidelines for Repairing Mobile A/C Systems

To minimize refrigerant emissions and have properly operating systems it is important that they be properly serviced. The following are some of the recommended industry procedures as identified in this manual. (Note: The following page numbers and excerpts are provided to assist the reader find relevant information regarding repair and replacement of components in the manual. The reader is referred to pertinent sections of the manual where the excerpts may be reviewed in their full context, along with additional relevant information.)

The following provides an overview and the reference page covering more detail.

Compressor

While the "fix" for a leaking or failed compressor is usually to replace it (rarely are compressors repaired), the manual includes important cautions and relevant information related to compressor replacement, such as:

Page 18 – To prevent damage to the compressor, it is important that the correct type and viscosity of lubricant (and correct amount of lubricant) is used in an A/C system.

Page 22 – With this limited amount of refrigerant, you can determine if the system has a leak, but you cannot determine if the system will provide cooling. If you intend to operate the compressor, the system must contain its specified amount of refrigerant.

Page 23 – Loss of refrigerant can reduce oil circulation - even before the low pressure switch or other sensor shuts down power to the compressor clutch. It is important to determine if there were multiple leak sources. Another leaking system part and loss of refrigerant could have caused the compressor failure.

Page 25 – It is important that dyes be safely and properly used. Excessive dye can result in compressor damage.

Page 26 – In-liquid-line filters can be installed to trap debris that may be in an A/C system after it has suffered a catastrophic compressor failure.

Page 28 – The only way to remove significant moisture from a system is to replace the receiver drier or accumulator.

Page 28 – Undercharges can result in poor cooling, and even worse, poor lubricant circulation, which can lead to compressor failures. Overcharges can result in high operating pressures, which can also cause poor cooling performance, and even component damage.

Page 29 – Lubricant circulation in the system relies upon a proper refrigerant charge, and inadequate refrigerant (and therefore lubricant) flow in the refrigerant circuit will result in increased compressor operating temperature. These higher operating temperatures can result in damage to the compressor, lubricant, and flexible hoses and seals.

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Condenser

As with the compressor the "fix" for a leaking or failed condenser is usually to replace it, and following are some important considerations that the technician should keep in mind:

Page 26 – Today's condensers have very tiny refrigerant multi-flow passages. This is why attempts to flush debris-clogged condensers are often not successful. (Note: The decision to flush or not to flush A/C systems or components is an important repair issue.)

Page 31 – Also, some replacement condensers require a change in system charge spec, usually a reduction.

Evaporator

The real challenge is finding leaks in the evaporator due to its location. If the evaporator is found to be leaking, it should be replaced with a new evaporator. The technology of current automotive evaporators is such that repair is not a viable option. Evaporator replacement involves significant labor, making a repeat failure particularly undesirable. For more information, review the following:

Page 22 – To prevent contamination, leak detection must only be done with the refrigerant that is specified for the system. Do not attempt to use shop air for leak detection purposes.

Page 23 – Leak testing of the evaporator core is a challenging task.

Page 28 – A system with an incorrect refrigerant charge may suffer unseen problems.

Accumulator or Receiver Drier

The accumulator or receiver-drier is important for controlling moisture in the A/C system and in the event of a mechanical failure, can become a collection point for foreign material, which could then be circulated in the system and cause further system damage. For more details regarding replacement of this component, see:

Page 5 – A/C systems contain desiccant material. Desiccant, which absorbs moisture in the system, is located in the receiver/drier or accumulator, or are integral in a cartridge or bag with the condenser.

Page 16 – To remove as much of the refrigerant as possible during the recovery process, systems equipped with orifice tubes and accumulators require more time than systems equipped with expansion valves/receiver driers.

Page 28 – The only way to remove significant moisture from a system is to replace the receiver-drier or accumulator.

Flexible Hose, Hose Coupling

Hoses can develop leaks at hose coupling assemblies, due to mechanical rub-through. In addition to hose failure, all system couplings or attachments that have sealing surfaces may fail and result in leaks. More information regarding hose assemblies and hose couplings can be found on the following pages:

Page 37 – All hoses used with mobile A/C system service equipment must be equipped with shut-off valves. The shut-off valves may be either manual or automatic. SAE standards stipulate that the shut-off valves must be located within 12 inches (30 cm) of the "vehicle end" of the service hose, but some equipment manufacturers incorporate the shut-off valve in their quick-couplers.

Page 37 – Air can be introduced into the refrigerant supply when refrigerant is recovered if there are any leaks in the A/C system or the service hoses.

Pages 41 and 42 –Information regarding repair of hose and proper hose coupling is addressed on these pages.

Page 48 – When the mobile industry changed refrigerants from CFC-12 to HFC-134a new unique quick couple service fittings were developed to reduce venting and possible mixing of refrigerants during service of mobile A/C systems. New unique quick couple service fittings have been developed for R744 (carbon dioxide) and HFC-152a mobile A/C systems and are identified in J639.

O-rings and Seals

O-rings and seals have a major role in refrigerant containment. More detail regarding these important A/C system components can be found on the following pages:

Page 5 – Changes in systems designs were required to assure that HFC-134a systems performed equal to CFC-12 systems. Some of these changes included new hose and seal materials compatible with HFC-134a and the lubricants used with it. The new hoses and seal designs also reduced leakage.

Page 13 – To help avoid skin contact, mineral oil should be used to coat o-rings and seals prior to installation. Also, since PAG lubricants absorb moisture, using mineral oil reduces the potential for fitting corrosion.

Page 14 – Recovery/recycling/recharge equipment should be checked frequently to ensure that no leaks exist within the internal refrigerant flow circuits, as well as the external hoses and seals.

O-rings and seals continued next page

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O-rings and seals continued

Page 22 – Also, using another refrigerant (like HCFC-22) could cause chemical damage to system components, such as the desiccant material. Since evacuation of the system may not remove all the HCFC-22, this can further result in seal, hose and lubricant damage.

Page 26 – This residual solvent can dilute the lubricant, which can lead to inadequate compressor lubrication and possible subsequent compressor failure. It could also possibly affect the chemical stability of the refrigerant, seals and hose materials.

Page 29 – These higher operating temperatures can result in damage to the compressor, lubricant, and flexible hoses and seals.

Page 41 – With smaller refrigerant charges, all the seals, joints and fittings have to be designed to leak far less.

Page 42 – As determined by the vehicle or system manufacturer, additional retrofit requirements and recommendations may include the installation of new o-rings and/or seals, new desiccant, a different lubricant, replacement of refrigerant controls, increased condenser capacity and other modifications.

Page 42 – There is no published information or industry-recognized tests to establish system cooling performance, system reliability, material compatibility or the potential for chemical damage to the system's lubricant, seals and hoses should a substitute refrigerant be installed in an HFC-134a system.

Page 51 – SAE J1662: "Compatibility of Retrofit Refrigerants with Air-Conditioning Materials"

Seals, hoses and "O" rings used in CFC-12 systems may not be compatible with some alternate refrigerants and could break down causing system failures.

Service Ports

Service port fittings will develop leaks from normal service operations, and replacement of service port caps is a critical but often overlooked step in preventing leaks. Following are pertinent references:

Page 15 – As a first step in service, always perform a visual inspection to spot obvious problems. Since the service port caps serve as the primary seal for the service ports, make sure that each service port in the system has a cap installed, and that the caps' seals are not damaged. Missing or damaged service port caps are major leak sources.

Page 45 – Connection and disconnection of service equipment often results in the release of a small amount of refrigerant at the service ports. If the refrigerant released in these circumstances is flammable, and there is a source of ignition nearby (such as a torch or pilot light on a gas appliance), a fire or explosion could occur.

Page 45 – CAUTION: ***FUEL INJECTION SYSTEMS ON MANY VEHICLES CONTAIN A SERVICE PORT THE SAME SIZE AS ONE OF THE CFC-12 A/C SYSTEM SERVICE PORTS. BE CAREFUL NOT TO ATTACH A/C SERVICE EQUIPMENT TO A VEHICLE'S FUEL SYSTEM!***

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Refrigerant Recycling and Service Procedures for Mobile Air Conditioning Technicians

INTRODUCTION

Before the 1990s, it was common practice during the service of mobile air conditioning systems to just add refrigerant to leaking systems. It was also common practice to vent the entire refrigerant charge to the atmosphere if the refrigeration system required any type of service which involved opening the refrigerant circuit. These practices were acceptable because refrigerant was relatively inexpensive and thought to be environmentally benign.

But, knowing what we do today about the role of CFC-12 in the degradation of the earth's protective ozone layer, and the potential of global warming, venting refrigerants is irresponsible and is not permitted. Under the Clean Air Act, this activity is illegal. In other rulings, the EPA prohibits the venting of other refrigerants, including HFC-134a and blend refrigerants containing HCFCs used in mobile air conditioning systems.

To protect the ozone layer, the United States, and over 180 other nations ratified the 1987 Montreal Protocol on Substances which Deplete the Ozone Layer. This landmark international agreement is designed to control the production and consumption of certain chlorofluorocarbon and halon compounds.

In the 1980s, mobile air conditioning systems used CFC-12 refrigerant. With the advent of the Montreal Protocol, the industry changed to HFC-134a. In 1990, the U.S. Clean Air Act addressed the refrigerants used in mobile air conditioning systems.

CFC-12 has both an ozone-depleting and Global Warming Potential (GWP). HFC-134a is not ozone-depleting, but is considered to have global warming potential. By late 1994, all new mobile air conditioning systems produced in the United States used HFC-134a. Blend refrigerants that were listed as acceptable by the EPA for servicing mobile air conditioning systems are covered by the venting prohibition and, like CFC-12 and HFC-134a, cannot be released into the atmosphere.

THE ENVIRONMENTAL ISSUES

Ozone is a pungent, slightly blue gas that absorbs certain wavelengths of the sun's radiation. Ozone is concentrated in a part of the atmosphere called the stratosphere. The stratosphere is located between 10 and 30 miles above the earth's surface. Stratospheric ozone should not be confused with ground level ozone, which is commonly referred to as smog.

The ozone layer acts as a shield against harmful solar Ultraviolet Beta (UVB) radiation. Ozone normally absorbs UVB. Decreasing the amount of stratospheric ozone results in higher levels of UVB reaching the earth's surface, and this increase can be harmful to humans, animals, plants, and the environment as a whole. It is estimated that for every percentage point that stratospheric ozone is reduced, exposure to ultraviolet radiation is increased by 1.5 to 2%.

Substances like chlorine, from synthetic chemicals called chlorofluorocarbons (CFCs), and bromine, from chemicals called halons, when released to the atmosphere, react in a way which reduces the amount of ozone in the strato-

CFCs were used for many different purposes, including refrigerants in mobile A/C systems prior to about 1992. Leaks and other releases allow them to enter the atmosphere.

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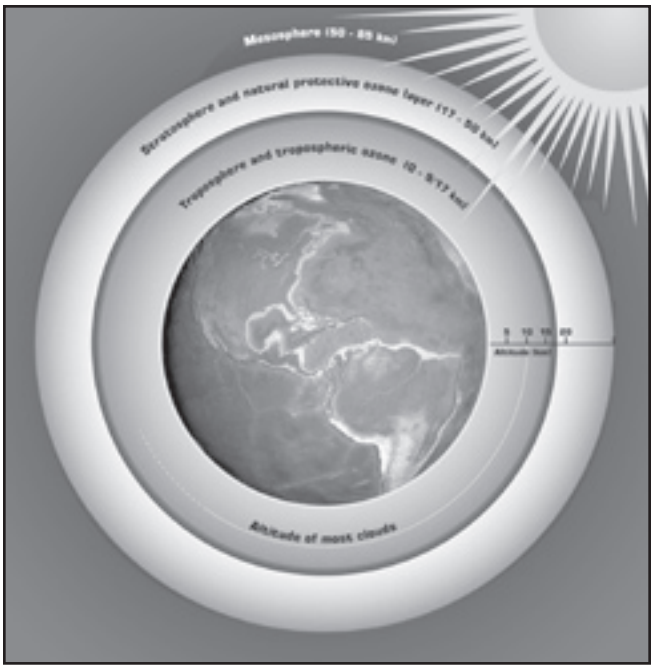
sphere. CFCs were used as blowing agents in plastic foam products (cushioning, insulation and packaging), as refrigerants, as solvents, as sterilants, and in aerosol applications. Additionally, halons are used as fire extinguishing agents.

A concern identified under the Montreal Protocol was that a significant reduction in ozone in the upper atmosphere could result in long-term increases in skin cancer and cataracts. It may also cause damage to the human immune system. The reduction of stratospheric ozone may also reduce crop yields and alter aquatic ecosystems.

Growing awareness about the threat to the global environment, and the type and amount of refrigerant used in mobile air conditioning systems has resulted in system design changes, new service procedures and equipment to reduce system lifetime emissions.


Mesosphere (50 - 80 km)
Stratosphere and natural protective ozone layer (17 - 50 km)
Troposphere and tropospheric ozone (0 - 17 km)
Altitude of most clouds

The ozone layer is located in the stratosphere about 10 to 30 miles (16 to 48 kilometers) above the earth's surface.

MORE ON OZONE DEPLETION

CFCs and their Affect on Ozone

Possible depletion of the ozone layer resulting from CFCs was first raised in 1974. Research indicated that chlorine released from CFCs could migrate to the stratosphere and destroy ozone molecules (Molina and Rowland, 1974).

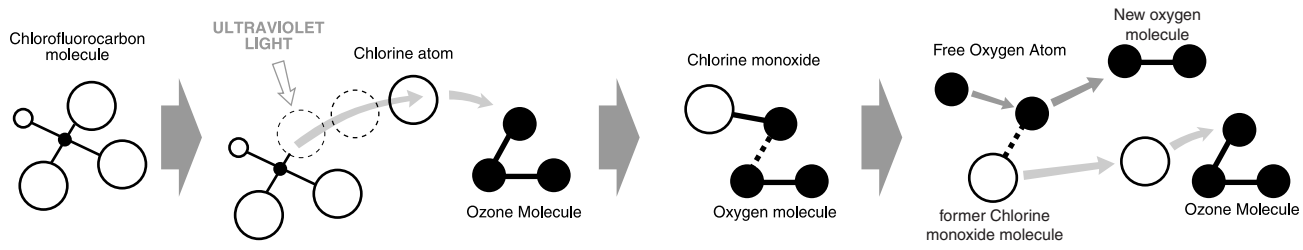
Some CFCs have an atmospheric lifetime of more than 120 years (which means they do not break down in the lower atmosphere). As a result, they migrate slowly to the stratosphere where higher energy radiation from sunlight strikes them, releasing chlorine.

The link between CFCs and ozone depletion is supported by scientific evidence. CFCs have been widely used, and when released, migrate to the upper atmosphere. Because CFCs are very stable, and heavier than air, they do not break down until they are carried by wind currents into the stratosphere, a process that can take as long as 10 years.

In the stratosphere, these chemicals absorb UV radiation, break apart, and react with ozone, taking away one oxygen atom and forming chlorine monoxide. Chlorine monoxide further breaks down ozone by pulling away a single oxygen atom, creating two oxygen molecules.

Once freed, the chlorine acts as a catalyst, repeatedly combining with, and breaking apart ozone molecules. It is believed that one CFC molecule can destroy as many as 100,000 ozone molecules.

CFC's ozone-degrading effect became more evident with the discovery of the Antarctic Ozone Hole. British research-



In the upper atmosphere, ultraviolet light breaks off a chlorine atom from a chlorofluorocarbon molecule.

The chlorine attacks an ozone molecule, breaking it apart. An ordinary oxygen molecule and a molecule of chlorine monoxide are formed.

A free oxygen atom breaks up the chlorine monoxide molecule. The chlorine atom is then free to repeat the process.

Chlorine atoms from CFCs break apart ozone molecules. This results in a reduction of stratospheric ozone.

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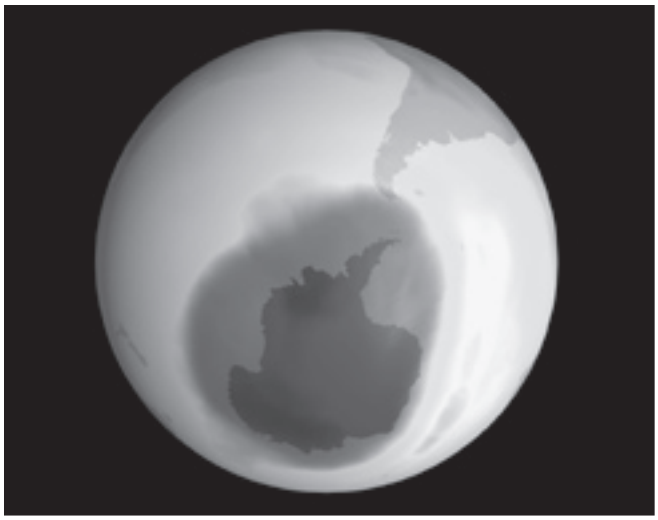


This shows how ozone depletion has resulted in an ozone hole located over the South Pole.

ers found that an accelerated deterioration of the ozone layer had been created by a combination of four elements: atmospheric ice crystals, upper atmospheric vortex winds, the change from total darkness to sunlight, AND damaging CFCs. The four factors, when combined together, made the ozone deterioration process even faster.

When scientists began studying ozone depletion in the early 1970s, they also investigated several natural phenomena, such as volcanoes and evaporation of seawater. Volcanoes produce hydrochloric acid. However, most volcanic discharges are not powerful enough to reach the stratosphere. Chlorine evaporation from seawater is dissolved in rain and does not reach the stratosphere. Chlorine produced by volcanoes or oceans does not leave the troposphere and poses no threat to the ozone layer. However, CFCs, being extremely stable, do not release chlorine until they reach the stratosphere.

In December, 1994, NASA announced that satellite data gathered over a three-year period confirmed that CFCs are the primary source of stratospheric chlorine.

Because of the long atmospheric lifetimes of CFCs, it will take many decades for the ozone layer to return to its former concentration. As CFC levels are reduced, the natural atmospheric process will rebuild the ozone level. Until that time, increased UV levels can lead to a greater chance of overexposure to UV radiation and the health and environmental problems that result.

Health and Environmental Effects

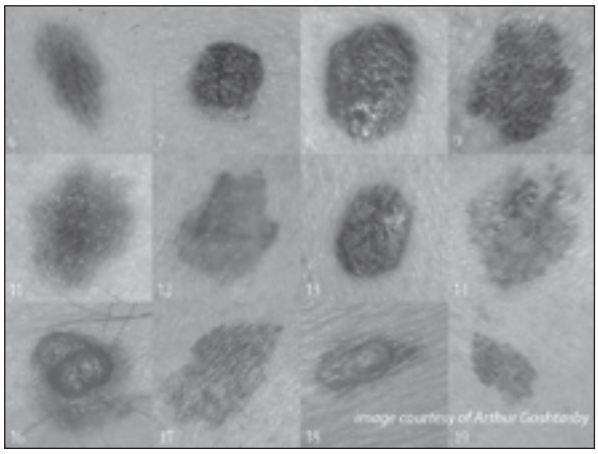
The Environmental Protection Agency's (EPA) assessment of the risks from ozone depletion has focused on the following issues:

- Increases in skin cancers
- Increases in cataracts
- Damage to the human immune system
- Damage to crops
- Damage to aquatic organisms
- Increases in ground level ozone
- Increased global warming

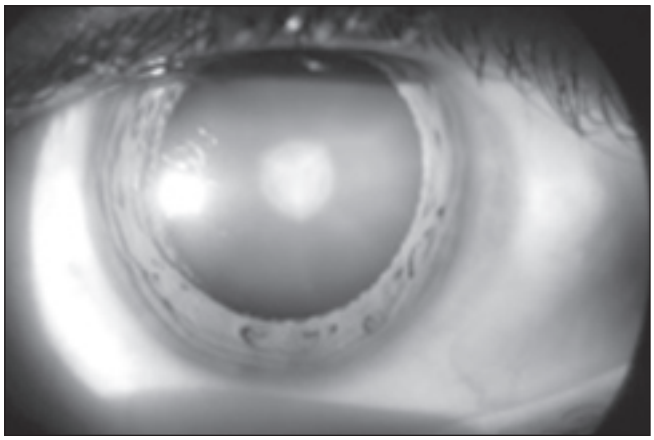
Human Health Effects

Skin cancer is a serious problem, and cases of three distinct types have increased because of depletion of the ozone layer. Basal and squamous cell skin cancers are the two most common types. If detected early, these cancers are treatable. Even so, approximately 1% of cases result in death. Malignant melanoma is far less common but substantially more harmful. Six out of seven skin cancer fatalities are due to melanoma.

Cataracts cloud the lens of the eye, thus limiting vision. Although cataracts develop for a variety of reasons, scientific evidence supports the conclusion that increased exposure to UV radiation can increase the number of people suffering from cataracts.



Types of skin cancer



Increased levels of UV radiation can contribute to the formation of cataracts.

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Damage to the immune system is another possible threat. Research suggests that exposure to UV radiation weakens the immune system's ability to fend off certain diseases.

Plant and Marine Effects

Crops and other ecosystems can also be adversely affected by increased exposure to UV radiation. In greenhouse studies, approximately two-thirds of the crops exposed to elevated levels of UV radiation proved sensitive.

Certain marine organisms may also be sensitive to increased exposure to UV radiation. Although it is difficult to design experiments replicating aquatic environments, research suggests that increased exposure to UV radiation can have adverse effects on productivity and species diversity.

Other Impacts

Ground-level Ozone - Stratospheric ozone depletion increases the rate of formation of ground-level ozone, a major component of smog.

Stratospheric ozone depletion can increase the rate of formation of ground-level ozone, which is a major component of smog.

Degradation of Polymers - Ozone depletion accelerates weathering (i.e. chalking, yellowing, and cracking) of plastics used in outdoor applications.

Climate Change - CFCs (and HFCs as well) are greenhouse gases which contribute to global warming and rising sea levels.

Global Problem

Ozone protection is a global concern. CFCs and halons have been produced in the United States, and in other developed countries, and are being used in nations around the world. Given their long atmospheric lifetimes, they have become widely dispersed over time. As a result, the release of these chemicals by one country can migrate up into the stratosphere, travel globally and adversely affect the health and welfare of other countries.

The United States, for example, has been one of the largest producers and consumers of the world's CFCs. Other nations also have been significant users.

Therefore, to protect the ozone layer, an international solution was critical.

Montreal Protocol

Recognizing the global nature of the problem, on September 16, 1987, in Montreal, Canada, 24 nations and the European Economic Community (EEC) signed the Montreal Protocol on Substances which Deplete the Ozone Layer. The U.S. and other countries signed the Protocol, agreeing to phase out production of ozone-depleting substances. The 1990 Clean Air Act Amendments incorporated the Protocol's original phase-out date: the year 2000. In 1992, then-President Bush pledged to halt almost all U.S. production of CFCs by the end of 1995.

The Chemicals

Listed below are chemicals controlled by the Montreal Protocol and their associated ODP (Ozone Depletion Potential) values as well as their GWP (Global Warming Potential) values. An ODP value is a measure of a chemical's relative ability to destroy ozone molecules in the stratosphere. A GWP is a measure of a chemical's relative ability to produce a global warming effect.

The higher the ODP value, the greater a chemical's potential to destroy ozone in the stratosphere. The higher the GWP value, the greater a chemical's influence on global warming.

Fully-Halogenated Chlorofluorocarbons

	ODP	GWP
CFC-11	1.0	4,680
CFC-12	1.0	10,720

Comparison to HFC-134a

	ODP	GWP
HFC-134a	0	1,410

Global Warming

Concerns regarding the global warming potential of HFC-134a led the European Union to ban the use of HFC-134a in mobile air conditioning starting in 2011. The global automotive industry and the U.S. EPA are evaluating possible use of replacement refrigerants.

These global concerns regarding the release of refrigerants during the service of mobile A/C systems have resulted in revised standards for service procedures and equipment.

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To reduce refrigerant emissions during service, new equipment and servicing procedures have been developed. Additionally, improved system designs will result in reduced refrigerant emissions and increased system operating efficiencies.

Field Study - Refrigerant Recovery and Reuse

Because of ozone depletion, industry efforts were directed toward determining if CFCs used in mobile air conditioning systems could be recycled for reuse. In the summer of 1988, the EPA, with the support of the Mobile Air Conditioning Society Worldwide (MACS) initiated a sampling program of used refrigerant from 227 vehicles located in four regions of the country. The vehicles included both low and high mileage examples, ones equipped with properly operating systems, as well as ones with failed compressors.

The chemical analysis of the refrigerant removed from these vehicles showed very little contamination. However, the data did identify moisture, refrigerant oil and non-condensable gases (air) as contaminants in used refrigerant, which could affect system performance and life.

From the field study results, the task force established specifications for recycled refrigerant, and in December 1988, asked the world's auto manufacturers to help determine and approve a level of purity for recycled refrigerant. The level of purity was established.

SAE developed recovery and recycling standards for equipment to meet refrigerant purity requirements for on-site processing and direct reuse in mobile A/C systems. Subsequently, vehicle and A/C system manufacturers accepted recycled CFC-12 and HFC-134a as meeting the appropriate SAE standard for service and warranty repairs.

While the actual recycling process may vary between machines and manufacturers, the manufacturers must certify the machines to the requirement for each refrigerant, and affix a label to the machine stating that it meets the standard of purity.

The Switch to HFC-134a Refrigerant

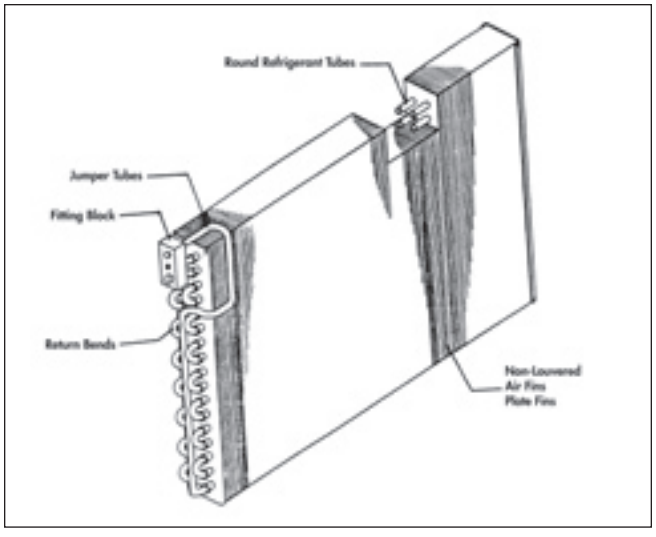
Starting with some 1992 models, with completion by the 1995 model year, HFC-134a replaced CFC-12. Changes in systems designs were required to assure that HFC-134a systems performed equal to CFC-12 systems. Some of these changes included new hose and seal materials compatible with HFC-134a and the lubricants used with it. The new hoses and seal designs also reduced leakage.

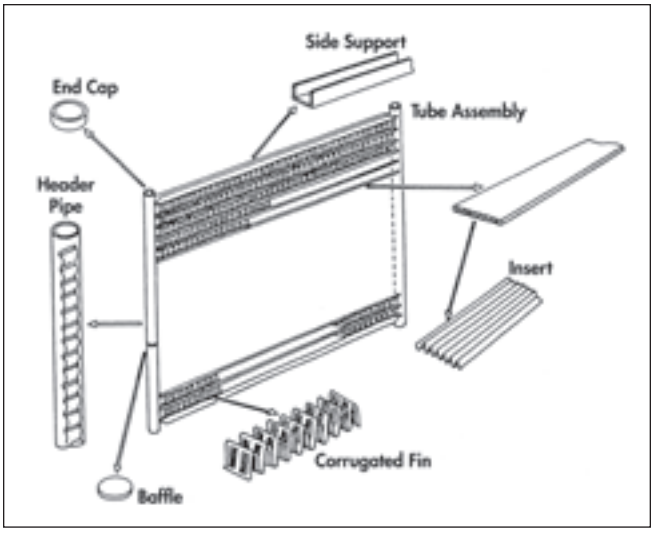
The most noticeable change, however, is increased condenser capacity, and increased airflow, to reduce system pressures at low speed operation and city traffic conditions. In general, condenser performance for HFC-134a systems has been increased by approximately 30% over that of CFC-12 systems, which resulted in comparable performance.

HFC-134a systems also require a new desiccant material. Desiccant, which absorbs moisture in the system, is located in the receiver/drier or accumulator, or integral in a cartridge or bag with the condenser.

CFC-12 systems used XH5 desiccant; HFC-134a systems require XH7 desiccant. Today, when a receiver/drier or accumulator is being replaced, it should contain XH7 desiccant, because it is compatible with both CFC-12 and HFC-134a.

HFC-134a does not provide the same level of lubricant circulation as CFC-12, so it is very important that the proper lubricant be used in HFC-134a systems. The industry is





The condensers used in HFC-134a systems are more efficient than the ones that were used in CFC-12 systems. The 3/8-inch tube-and-fin condenser shown on the left is an example of the type that was used for many years in CFC -12 systems. The parallel flow/multi-flow condenser on the right is representative of the type of condensers used in many HFC-134a systems.

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using many different formulations of Polyalkylene Glycol (PAG) lubricants with various additives. SAE standard J639 requires vehicle and A/C system manufacturers to identify their recommended lubricant on the system's information label. It is recommended that different types of PAG lubricants not be mixed.

A vehicle's A/C system information label lists the type of lubricating oil that the system requires.

FEDERAL REGULATIONS AFFECTING MOBILE A/C SYSTEM SERVICE

Section 609 of the Clean Air Act gives the EPA authority to establish standards and requirements regarding servicing of mobile A/C systems.

On July 14, 1992, the EPA published the final rules (regulations) implementing this section of the Act (40 CFR Part 82). Under the U.S. Clean Air Act, it is illegal to vent chemicals used in mobile air conditioning systems into the atmosphere. Therefore, on-site recovery of the refrigerant, prior to service, is required.

Equipment Use

Since January 1, 1992, for CFC-12, and November 15, 1995 for HFC-134a and other mobile A/C refrigerants, any person (employed technician or do-it-yourselfer) servicing the mobile air conditioning pressurized refrigerant circuit for consideration must comply with the Clean Air Act and must use either refrigerant recovery/recycling or recovery-only equipment approved by EPA. Those working "for consideration" (receiving monetary value) who open the refrigerant circuit must be certified by an EPA-approved organization to legally use such equipment to service the system.

Mobile A/C system refrigerants must be recovered with the appropriate recovery machine. It is illegal to vent them to the atmosphere.

Persons working on their own mobile air conditioning system are not covered under this rule and can add refrigerant without being certified. However, ***anyone found to intentionally release refrigerant into the atmosphere under any circumstance during the repair, maintenance or service of mobile air conditioning systems, can be fined.***

Fleets of vehicles, whether private, federal, state or local government owned, are subject to the regulations because the technicians performing the service are paid. Other examples of establishments covered by the regulations include, but are not limited to: independent repair shops, service stations, fleet shops, body shops, chain or franchised repair shops, new and used car and truck dealers, rental establishments, radiator repair shops, mobile repair operations, vocational technical schools (because instructors are paid), farm equipment dealerships and fleets of vehicles at airports.

Technician Training and Certification Requirements

Technicians using approved equipment must be trained and certified by an EPA-approved organization. To be certified, technicians must pass a test demonstrating their knowledge in the use of refrigerant recovery/recycling equipment, the EPA's regulatory requirements, the importance of refrigerant containment and the effects of ozone depletion and environmental change.

Overlap Between Sections 608 and 609 of the Clean Air Act

Section 608 of the Clean Air Act directs the EPA to establish requirements to prevent the release of ozone-depleting

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and certain other refrigerants during the servicing, repair or disposal of appliances and industrial process refrigeration systems. This includes the scrapping/salvage of vehicles that have a mobile A/C system. Section 608 covers procedures involving motor vehicle air conditioners (MVACs) that are not covered by Section 609, such as the disposal of MVACs. Below is information concerning specific areas where the overlap between these two sets of regulations may require clarification.

Section 609 of the Clean Air Act establishes standards specifically for the service of MVACs. MVACs are included in the definition of appliances under the stipulations put forth in Section 608; however, since their service and repair are regulated under Section 609, they are not subject to the servicing requirements put forth in Section 608.

Both regulations require that technicians become certified. Technicians who repair or service MVACs must be trained and certified by an EPA-approved Section 609 program. These programs are specifically designed to cover MVAC refrigerant recovery, recycling and charging equipment and procedures in accordance with SAE Standards and Section 609 regulatory requirements. After completing a required training program, MVAC technicians must pass a test to become certified. These tests are different from the Section 608 certification tests.

Under Section 608, the EPA has established four types of certification for technicians that service and repair appliances other than MVACs. To be certified, technicians must pass a test for the appropriate appliances. All training and review classes for Section 608 are voluntary; only passing the test is mandatory. The four categories of certification are:

- **Type I:** Small appliances
- **Type II:** High-pressure appliances, except small appliances & MVACs
- **Type III:** Low-pressure appliances
- **Type IV** (Universal): All appliances except MVACs

People who service or repair MVAC-like appliances (e.g. farm equipment and other off-road vehicles) can choose to be certified by either the Section 609 program or under Section 608 Type II. However, due to the similarities between MVAC and MVAC-like appliances, the EPA recommends that technicians servicing MVAC-like appliances consider certification under Section 609.

Note: While buses using CFC-12 are MVACs, buses and other vehicles using HCFC-22 as refrigerant are not classified as MVACs or MVAC-like appliances, but rather as high-pressure equipment covered under Type II of the Section 608 test. Certification under Section 608 is also required to service cargo refrigeration equipment.

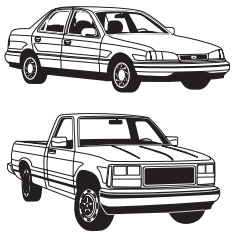
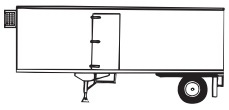
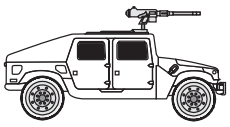
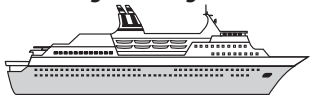
Mobile A/C Service Equipment Certification, Operation and Refrigerant Purity

The SAE Interior Climate Control Standards Committee developed documents containing the procedures to be used for proper handling and use of CFC-12 and HFC-134a in mobile A/C systems. The documents include:

CFC-12 SAE Documents

- SAE J1989: Service Procedures
- SAE J1990: Specifications for Recovery/Recycling Equipment
- SAE J1991: Standard of Purity

608 vs. 609

MVAC (609)	MVAC-like (609)*	Appliance (608)
Passenger Cars and Trucks 	Buses	Trains
	Farm Tractors/implements	Aircraft - Passenger & Cargo
	Off-road Equipment	Refrigerated Trailers 
	Military vehicles (passenger)  *if R-22, then 608	Ship/boat - Passenger & Cargo 

Do you need Section 609 Certification, Section 608 Certification, or maybe both? This chart will tell you which type(s) you need.

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- SAE J2196: Service Hoses for Automotive Air Conditioning
- SAE J2209: CFC-12 Recovery-only Equipment

HFC-134a SAE Documents

- SAE J1732: HFC-134a Recovery-only Equipment (superseded by SAE J2810)
- SAE J2099: Standard of Purity
- SAE J2196: Service Hoses for Automotive Air Conditioning
- SAE J2197: HFC-134a (R134a) Service Hose Fittings for Automotive Air Conditioning Service Equipment
- SAE J2210: Specifications for Recovery/Recycling Equipment (superseded by SAE J2788)
- SAE J2211: Service Procedures
- SAE J2776: Refrigerant Purity and Container Requirements for New HFC-134a 1,1,1,2 – Tetrafluoroethane Refrigerant Used in Mobile Air Conditioning Systems
- SAE J2788: Specifications for Recovery/Recycling/ Recharge Equipment
- SAE J2810: HFC-134a Recovery-only Equipment

Dual Refrigerant Recovery/Recycling Equipment (CFC-12/HFC-134a)

- SAE J1770: CFC-12/HFC-134a Recovery/Recycling Equipment

More Complete Refrigerant Recovery

Ongoing studies aimed at reducing refrigerant emissions determined that existing equipment did not remove the entire refrigerant charge during recovery. Because of this, new SAE standards for recovery and recharge equipment were established.

In 2007 recovery/recycling equipment standard J2210 was superseded by SAE J2788. The new J2788 equipment provides more complete refrigerant recovery, and also establishes refrigerant charging requirements providing greater accuracy. New recovery/recycling equipment manufactured or imported after January 2008 must be certified to J2788 requirements.

Also in 2007, recovery-only equipment standard SAE J1732 was superseded by SAE J2810. The new J2810 equipment provides more complete refrigerant recovery. New recovery-only equipment manufactured or imported after Oct. 31, 2008 must be certified to J2810.

Purity of Recycled CFC-12

The SAE J1991 standard of purity for on-site recycled CFC-12 states that the refrigerant shall not exceed the following levels of contaminants:

- Moisture: 15 Parts Per Million (PPM) by weight
- Oil: 4000 PPM by weight
- Air (non-condensable gases): 330 PPM by weight

EPA regulations require that certified CFC-12 recovery/recycling equipment must conform to the specifications listed in SAE standard J1990. The equipment must also have a label, which states: "Design certified for compliance with SAE J1991."

Recycling vs. Reclaiming

Recycling versus reclaiming refrigerant . . . there is a difference!

Recycled refrigerant is that which has been processed on-site at a service facility, using automotive recycling equipment certified to the appropriate SAE J standard.

Reclaimed refrigerant is that which has been sent to an EPA-listed reclamation facility, where it is processed and returned to a state, which meets the appropriate ARI 700 specification.

The standards of purity for reclaimed refrigerant are much higher than those for recycled refrigerant.

Please Note!

Recovery/recycling equipment is not designed to recycle or separate contaminated refrigerants. Contaminated or unknown refrigerant must be removed from a system using dedicated recovery-only equipment, and properly disposed of. Under federal law, contaminated refrigerant cannot be vented.

Purity of Recycled HFC-134a

The SAE J2099 standard of purity for on-site recycled HFC-134a states that the refrigerant shall not exceed the following levels of contaminants:

- Moisture: 50 PPM by weight
- Oil: 500 PPM by weight
- Air (non-condensable gases): 150 PPM by weight

EPA regulations require that certified HFC-134a recovery/recycling equipment must conform to the specifications listed in the appropriate standard. The equipment must have a label, which states: "Design certified for compliance with SAE J2210 or J2788."

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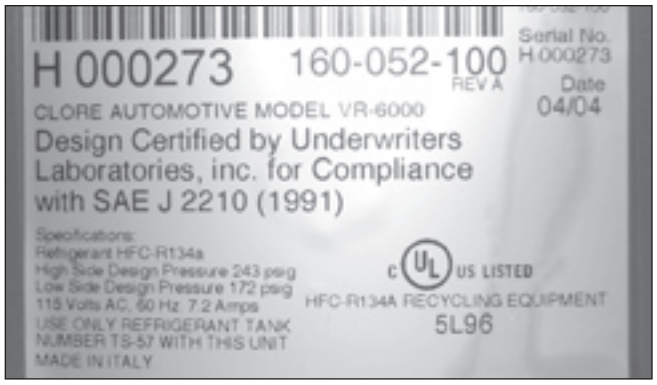

Recovery/recycling machines used for mobile A/C system service must bear a label showing that they meet the requirements of the appropriate SAE standard.

Certified by Underwriters Laboratories, Inc. to meet SAE J2788 superceding J2210.

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Equipment manufactured after Jan. 1, 2008 will have a label similar to the above, noting that the equipment meets SAE Standard J2788, superseding J2210.

Service Equipment Hoses

All hoses used with mobile A/C system service equipment must be equipped with shut-off valves. The shut-off valves may be either manual or automatic. SAE standards stipulate that the shut-off valves must be located within 12 inches (30 cm) of the "vehicle end" of the service hose, but some equipment manufacturers incorporate the shut-off valve in their quick-couplers. These automatically shut off the flow of refrigerant when the hoses are disconnected.

Fittings that are unique to individual refrigerants must be permanently attached to the "vehicle end" of service hoses. Adapters for different refrigerants, different systems, or different service port designs may not be attached to service hoses, then removed and replaced with adapters for a different refrigerant.

Equipment Certification

To comply with Section 609 of the Clean Air Act, recovery/recycling equipment must be certified to SAE specifications. Recovery/recycling equipment used for commercial refrigeration, and not certified to SAE standards, does not meet the federal compliance requirements and cannot be used. To prevent refrigerant contamination, recovery/recycling equipment must only be used with one designated refrigerant.

Equipment Registration

It is the responsibility of the recovery/recycling equipment owner, or another responsible officer, to notify the EPA that they own approved equipment. The information in the following bullet points must be mailed to the EPA regional office for the state or territory in which the establishment is located (see pages 53 and 54).

- Name, address and telephone number of the establishment where the recovery/recycling equipment is located;
- Name brand, model number, year and serial number(s) of the equipment acquired for use at the above establishment.

The above information can be submitted on a plain sheet of paper, or can be submitted on a special form the EPA provides for this purpose. A copy of this form is provided in the back of this manual. You may photocopy it for your use.

The person responsible for the equipment must sign the form. The person who signs is certifying that they are responsible for the equipment, that each individual assigned to use the equipment is properly trained and certified, and that the information provided is true and correct. The repair facility is required to file this certification only one time. ***The shop owner should keep a copy of the equipment certification on file.***

Other Record Keeping Requirements

Note: All records listed below must be retained for a period of three years.

- As mentioned above, any person who owns approved refrigerant recovery/recycling equipment and provides service for a monetary value, must have records demonstrating that all persons assigned to operate the equipment are currently certified.
- Any person who owns approved refrigerant recovery or recovery/recycling equipment must maintain records of the name and address of any facility to which refrigerant is sent.
- Any person who sells Class I substances (chlorofluorocarbons/CFCs) or Class II substances (hydrochlorofluorocarbons/HCFCs) for use as mobile A/C system refrigerants must prominently display a sign which states: "It is a violation of federal law to sell containers of Class I and Class II refrigerant to any per-

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son who is not properly trained and certified to operate approved refrigerant recovery/recycling equipment."

- Section 608 of the Clean Air Act requires that all persons who sell CFC and HCFC refrigerants must retain invoices that list the name of the purchaser, the date of the sale, and the quantity of refrigerant purchased. However, since the sale of small containers of CFC-12 is restricted to technicians certified under Section 609, these record-keeping requirements do not apply to the sale of small containers of CFC-12.
- Mobile A/C service facilities must allow an authorized representative of the EPA entry onto their premises, (upon presentation of appropriate credentials) and give the authorized representative access to all required records.

Further Mobile A/C Service Rules and Regulations

- Every compensated technician that opens the refrigerant circuit must be certified. This includes technicians that only add refrigerant to "top off" a system. Facilities that typically only change or add fluids, such as lube-oil-filter operations, must have certified technicians and equipment.
- All listed mobile A/C system refrigerants removed during service cannot be vented to the atmosphere. Alternate refrigerants currently listed by EPA cannot be vented and must be recovered and properly disposed of, since EPA has not approved on-site recycling equipment for these alternative refrigerants. (Recovery and disposal of any future alternate refrigerant(s) identified as acceptable by the U.S. EPA will also likely be required.)
- Recovery-only equipment for Significant New Alternatives Program-listed (SNAP) alternate refrigerants must meet EPA and/or SAE equipment standards.
- It is also permissible to only recover CFC-12 and HFC-134a and other alternate replacement refrigerants. In this circumstance, the refrigerant must be sent off-site for recycling, reprocessing (reclaim) or disposal.
- CFC-12 and HFC-134a removed from systems must be recycled before it can be re-used, even if it is to be reinstalled into the same system from which it was removed. Blends must be recovered and sent off-site for proper disposal.
- Under federal law, it is legal to add refrigerant to a pre-existing leaking system. However, some states and local municipalities may have laws prohibiting this practice. It is the technician's responsibility to find out if a more stringent policy is applicable in their location.
- It is not required under federal regulations to remove refrigerant from a leaking system. However, this action may be required under state and local laws. It is the technician's responsibility to find out if a more stringent policy is applicable in their location.

Service facilities may adopt a policy to not add refrigerant to leaking systems, but the policy should be explained to the customer, including in the explanation the fact that the policy is not a federal or local governmental requirement.

Technicians should offer to fix leaks in air conditioning systems. It helps protect the environment and conserves refrigerant supplies. In addition, eliminating the system leakage can prolong the life of the A/C system. It is not correct, however, to state or imply that the leak repair is required under federal law. Doing so would constitute consumer fraud. It is your responsibility to determine if additional regional requirements apply.

If a customer arrives with refrigerant in their A/C system, and a technician removes it, then the customer declines that any further services be performed, the technician must return to the system the refrigerant that was in the system when it arrived, unless the customer agrees to its removal.

Regulations Applicable to Vehicle Salvage and/or Disposal Facilities

Vehicle salvage and disposal facilities must remove refrigerants from salvaged or scrapped mobile A/C systems. Salvage and disposal facilities that have certified recovery equipment can recover refrigerant at their facility and also move the equipment to other salvage and/or disposal facilities to recover refrigerant.

If CFC-12, this refrigerant can be sold to technicians certified under section 609. If HFC-134a, it can be sold to anyone wishing to purchase it. The salvage employee does not have to be certified to perform this operation. However, an uncertified person, working for consideration, cannot charge these refrigerants into a mobile A/C system, and the refrigerants must be recycled before reuse.

Refrigerant must be recovered from the A/C systems in scrapped vehicles before final disposal.

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Section 609 certified technicians that are not employed by the salvage or disposal facility can remove CFC-12 and HFC-134a from mobile A/C systems at the salvage and/or disposal facility. The refrigerant recovered must be recycled before reuse in other vehicles. Since there is no requirement to identify the purity of this refrigerant, or label tanks as containing refrigerant removed from vehicles at these facilities, it is important to keep in mind that any refrigerant removed from vehicles at salvage and disposal facilities can be contaminated.

Salvage and disposal facilities must keep records documenting when and if someone not directly employed by them removed refrigerant from vehicles at their facility. If applicable, they must also keep records documenting the sale of ozone-depleting refrigerants.

A Word on Recovery-only Equipment

The operation of recovery-only equipment is similar to the recovery feature of recovery/recycling equipment. However, recovery-only equipment is designed for the sole purpose of removing refrigerant from a system; it does not recycle refrigerant for reuse. Before it can be reused, the refrigerant must be recycled through use of a recovery/recycling machine which meets the appropriate SAE standard (for either CFC-12 or HFC-134a), or sent off-site to be reprocessed to the appropriate Air-Conditioning and Refrigeration Institute (ARI) ARI 700 specification. If refrigerant is sent off-site, records indicating where the refrigerant was sent must be maintained for three years.

CFC-12 recovery-only (and recovery/recycling) equipment and its refrigerant tanks have SAE 3/8-inch service fittings; HFC-134a recovery-only (and recovery/recycling) equipment and tank fittings have 1/2-inch Acme threads. Do not use adapter fittings with recovery-only machines or their tanks. Use of adapter fittings could result in contamination of refrigerant as well as A/C systems.

Tanks designated for use with recovery-only machines are gray in color, with a yellow top, and an identification label which reads "DIRTY (CFC-12 or HFC-134a) • DO NOT USE: MUST BE REPROCESSED." This is a safety measure to prevent possible direct reuse of non-recycled refrigerant.

Like recovery/recycling machines, recovery-only equipment must be equipped with a device to allow the operator to determine how much lubricant was removed during the recovery process.

Tax on CFC-12

On January 1 of each year, businesses with an inventory, or floor stock, of 400 pounds of CFC-12 or more, are required

Important Dates

Jan. 1, 1992: Since this date, containment and recycling of CFC-12 and HCFC refrigerants has been required.

Nov. 15, 1992: Since this date, sales of containers of CFCs under 20 pounds to anyone other than certified Section 609 technicians has been prohibited.

Nov. 14, 1994: Since this date, the sale of ozone-depleting refrigerants in any size container is restricted to certified technicians.

July 1995: Since this date, any CFC-12 mobile air conditioning system that is converted (retrofitted) to use an EPA accepted alternate refrigerant must have installed the appropriate unique service fittings and label listed for that refrigerant.

Nov. 15, 1995: Since this date, recovery of all mobile A/C system refrigerants has been required.

It must be noted that the above regulations apply no matter where a system is undergoing service, whether it be in a shop, or at an "off-site" location, such as a farm field, construction site, etc. Approved recovery-only, or recovery/recycling equipment can, and must be used any time refrigerant must be removed from a system for any reason.

Notes:

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to report their inventory and pay the difference between the prior year tax rate per pound. Each year, the floor tax increases 45 cents on each pound of refrigerant in stock. (Refrigerant recycled on-site from mobile A/C systems is not taxable.)

The floor stock tax on ozone-depleting chemicals is due and payable without assessment or notice on or before June 30. The tax must be deposited, together with Form 8109, Federal Tax Coupon, at an authorized depository of the Federal Reserve Bank serving the taxpayer's area.

If a businesses' inventory is 399 pounds or less, no tax payment is required. If inventory is 400 pounds or more, tax is required on all of the refrigerant – the first 399 pounds is not exempted.

Every person liable for the floor stocks tax must file a return of tax on Form 720, Quarterly Federal Excise Tax Return, to which Form 6627, Environmental Taxes, is attached, by June 30.

Note: Consult your tax advisor for additional information.

Imported Used and Recycled Refrigerant

Since January 1, 1996, new CFC refrigerant cannot be imported. However, it is permissible to import used or recycled CFC refrigerant. There is no federal requirement that containers of used or recycled refrigerant must be labeled to identify content or purity.

CFC-12 Supply – Future of CFC-12 Systems

Retrofitting of some of the CFC-12 fleet, and continuing availability of CFC-12, has allowed continued servicing of vehicles that were originally designed to use it. Until it is no longer available, it is legal to store and use CFC-12 for servicing mobile A/C systems. However, only technicians certified under section 608 or 609 of the Clean Air Act may purchase it.

For more information on EPA regulations applicable to mobile A/C system service, visit www.epa.gov/ozone/title6/609, or call the EPA's Stratospheric Ozone Protection Hotline at 800-296-1996.

Montreal Protocol Working as Planned, Scientists Say

In August 2006, scientists said the ozone layer of the Earth's atmosphere appears to have stopped thinning, a clear sign that a 19-year-old pact to phase out man-made, ozone-destroying gases is working. The research team, led by Eun-Su Yang of the Georgia Institute of Technology, concluded that the ozone layer outside of the Earth's polar regions stopped thinning around 1997, ending a steady decline since 1979.

"These results confirm the Montreal Protocol and its amendments have succeeded in stopping the loss of ozone in the stratosphere," said Yang, whose study appeared in the September 9, 2006 issue of the Journal of Geophysical Research. "At the current recovery rate, the atmospheric modeling community's best estimates predict the global ozone layer could be restored to 1980 levels."

In fact, scientists with the World Meteorological Organization and the United Nations Environment Programme concur that the ozone layer over the planet's inhabited northern and southern mid-latitude areas should reach a pre-1980 recovery level by 2049.

– Excerpt from *Greenwire*, 31 August 2006.
E & E Publishing, LLC

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SERVICE PROCEDURES FOR MOBILE AIR CONDITIONING SYSTEMS

Caution: When using recovery/recycling/recharge equipment, while it is very important to follow the general service procedures outlined in this manual, it is also very important to follow your equipment's manufacturer's instructions. Failure to follow these instructions could result in personal injury, damage to the equipment or A/C systems, or improper or inadequate refrigerant recovery, recycling and containment.

Safety Precautions & Warnings

1. ALWAYS wear eye protection when servicing air conditioning systems or handling refrigerant.
2. Avoid breathing refrigerant and lubricant vapor or mist. Exposure may irritate eyes, nose and throat. If accidental discharge occurs, ventilate the work area.
3. Do not allow refrigerants to come in contact with open flames and high-temperature surfaces. Decomposition is hazardous, and can occur if refrigerant is exposed to high temperatures (open flames, hot metal surfaces, etc.)
4. HFC-134a is not flammable at normal ambient temperatures and atmospheric pressure. However, tests have shown it to be combustible at certain pressures and ambient temperatures when mixed with air under pressure in a sealed environment. Service equipment or vehicle A/C systems should not be pressure tested or leak tested with compressed air.
5. PAG lubricant is hygroscopic (absorbs moisture). Containers must be kept tightly closed.
6. PAG lubricant can be a skin irritant. Protective impervious gloves are required to prevent lubricant contact with the skin. To help avoid skin contact, mineral oil should be used to coat o-rings and seals prior to installation. Also, since PAG lubricants absorb moisture, using mineral oil reduces the potential for fitting corrosion.
7. PAG lubricants can cause damage to paint, plastic parts, engine drive belts and coolant hoses. Care should be taken to prevent PAG lubricants from coming into contact with these items.
8. Failure to follow instructions provided by A/C system service equipment manufacturers could result in personal injury or equipment damage.
9. To prevent refrigerant cross-contamination, use separate service equipment for each refrigerant. Lubricant and refrigerant left in hoses and equipment can be a source of cross-contamination.
10. NEVER transfer refrigerants to a cylinder or tank unless it is Department of Transportation approved for refilling. DOT approval is indicated by the designation "DOT 4BA" or "DOT 4BW" stamped on a tank's collar (handle).
11. If a refrigerant tank is overfilled, it may explode. To prevent this from occurring, when transferring refrigerant into a tank, the safe filling level must be controlled by weight, and must not exceed 60% of the tank's gross weight rating.
12. NEVER perform service on recovery/recycling/recharge equipment (other than routine maintenance) without first consulting authorized service personnel. The removal of internal fittings and filters can cause the escape of refrigerant under pressure.
13. NEVER perform maintenance or service on recovery/recycling/recharge equipment with the unit plugged into electric power unless directed otherwise.
14. Avoid using extension cords with recovery/recycling/recharge equipment. If this is unavoidable, use a minimum length, 3-wire (No. 14 AWG minimum) cord with a ground circuit. To prevent shock hazards and reduce the risk of fire, make sure the extension cord is in good condition (not worn or frayed) with the ground circuit intact.
15. Recovery/recycling/recharge equipment often contains parts that may produce arcs or sparks. Do not use this equipment near flammable liquids or vapors.
16. Fuel injection systems on vehicles contain a service port the same size as one of the CFC-12 A/C system service ports. Be careful not to attach A/C service equipment to a vehicle's fuel injection system.

Additional health and safety information may be obtained from equipment, refrigerant and lubricant manufacturers. Refer to their instruction manuals and Material Safety Data Sheets.

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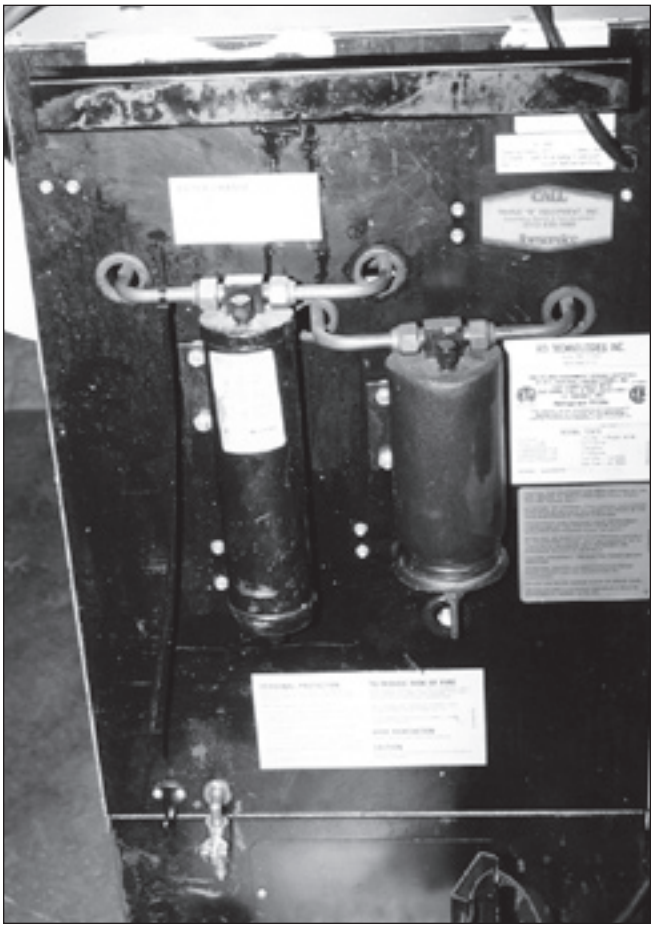
Maintaining Your Refrigerant Recovery/Recycling/ Recharge Equipment

Recovery/recycling/recharge equipment should be checked frequently to ensure that no leaks exist within the internal refrigerant flow circuits, as well as the external hoses and seals. Filters/driers must also be replaced in accordance with the machine manufacturer's specifications (check the equipment manual for filter location). Regular maintenance of your recovery/recycling/recharge machines should help to ensure that the SAE standards of purity for recycled refrigerant are met.

R/R/R machine internal plumbing must be periodically checked to make sure no leaks are present.

The seals on service equipment hoses must be frequently inspected for damage and replaced when necessary. This shows a comparison between a new seal (left) and a used one that is swelled and distorted (right).



R/R/R machine filters/driers must be replaced in accordance with the machine manufacturer's recommendations.

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Refrigerant Recovery and Recycling Procedures

Before You Begin . . .

Refrigerant Identifiers

A refrigerant identifier can help alert you to air conditioning system refrigerant contamination problems. The service industry and EPA strongly recommend, but do not require the use of this equipment. You can also use an identifier to help confirm what type of refrigerant is in a container. The identifier should conform to the specifications outlined in SAE J1771; this assures that the unit correctly identifies refrigerants. Keep in mind however, that even the best identifier may not be capable of indicating all of the possible combinations of chemicals that may be in an A/C system or storage tank. The identifier cannot determine if the refrigerant meets the SAE J2776 purity requirements.

While not required by law, the use of a refrigerant identifier is strongly recommended. It can help you determine if a vehicle contains contaminated refrigerant that you would not want inside your recovery machine. Identifiers can also provide an accurate indication concerning the amount of air that may be in an A/C system or storage tank.

Ensure System Integrity

As a first step in service, always perform a visual inspection to spot obvious problems. Since the service port caps serve as the primary seal for the service ports, make sure that each service port in the system has a cap installed, and that the caps' seals are not damaged. Missing or damaged service port caps are major leak sources. After service on the system is completed, make sure that each service port has a cap reinstalled, and that all of the caps seal properly.

Check for Pressure in the System

It would make no sense to attempt refrigerant recovery from a system that contains no refrigerant. Because of this, always check to see if the system has pressure by installing a pressure gauge on a system service port before starting a recovery process.

Before connecting service equipment, always perform a visual inspection of the A/C system to spot any obvious problems.

The caps are the service ports' primary seal against refrigerant leakage. Always make sure that every service port has one in place.

If a system contains no pressure, it is a safe assumption that the refrigerant has leaked out, and one of your first steps in service should be trying to track down a leak or leaks in the system.

If a system has some pressure but contains an unknown amount of refrigerant, some additional refrigerant can be added to check the system's operation. It is advisable, to provide the best system diagnosis, that the remaining refrigerant be recovered and the factory charge amount of refrigerant be added. If further inspection reveals a leak, but the customer declines to have repairs performed, the following options can be considered under current federal law:

Option 1: Under Section 609, the service facility can charge the customer for the inspection and added refrigerant and return their vehicle to them; there is no EPA requirement that refrigerant must be removed from a leaking system.

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Option 2: If the leaking system is not repaired, it must be returned to the customer with at least the same amount of refrigerant that it contained upon initial inspection. (Note: Some state and local laws have additional requirements regarding this aspect of A/C service.)

If the A/C system had no pressure at first inspection, any refrigerant added to the system is owned by the service facility. If the facility has a policy not to charge leaking systems, this is explained to the customer up front, and the customer declines to have the leaking system repaired, all added refrigerant can be removed.

Refrigerant added to a system for performance or leak testing cannot be vented to the atmosphere. It must be recovered.

The Effect of System Design on the Refrigerant Recovery Process

When refrigerant is removed from the system, the lowering of pressure results in some of the system components becoming cooler. This component cooling effect makes complete refrigerant removal in a short period of time more difficult.

To remove as much of the refrigerant as possible during the recovery process, systems equipped with orifice tubes and accumulators require more time than systems equipped with expansion valves/receiver driers. This is mainly because of the design differences between accumulators and receiver driers (being larger than receiver driers, accumulators, located in the low pressure side of the system, hold more refrigerant and oil than do receiver/driers).

During the recovery process, as the system is drawn into a vacuum, and pressure in the accumulator is lowered, the accumulator becomes very cold, with external frost sometimes visible on the accumulator. This makes it even more difficult to extract remaining refrigerant from it. If liquid refrigerant has not been removed and the refrigerant lines are opened, as the accumulator warms, a sudden release of refrigerant and oil can occur.

Heating the accumulator with devices such as a hair dryer or electric heating pad will raise the pressure in the accumulator and reduce the amount of time necessary for refrigerant removal.

When recovering refrigerant from any mobile A/C system, continue the recovery process until the system has been reduced from a pressure to a vacuum. At this point, pause operation of the recovery machine for five minutes, and check A/C system pressure. If pressure has risen above vacuum, additional recovery is required to remove remaining refrigerant. Repeat the recovery process until the vacuum remains stable, without rising, for two minutes.

Heating an accumulator during refrigerant recovery is a good idea. The heat will raise pressure inside the accumulator, allowing it to more easily outgas refrigerant it contains. This will reduce the amount of time necessary for more complete refrigerant removal.

Many recovery/recycling machines have a built-in five-minute wait period after the system is first drawn into a vacuum, and if a rise in system pressure is sensed, will automatically repeat the recovery process until the system will remain at a stable vacuum.

Cautions:

1. ***At no time should an open flame torch be used to heat the accumulator.***
2. ***All refrigerant must be removed before opening any of the system's connections.***

More Complete Refrigerant Recovery

The amount of refrigerant you can recover from a system depends on how much is in the system, of course, but also ambient temperature, the technique you use, and the performance of the recovery machine itself. When you try to draw out the refrigerant, the vacuum lowers the temperatures in the system; the oil chills and forms a virtually impenetrable blanket over some of the refrigerant.

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Engine Pre-Heat for Refrigerant Removal Procedure

The following procedure will aid in refrigerant removal when the work area is cool and J2210 and J1732 recovery equipment is being used. In general if the work area is warmer than 90° F (32° C) this procedure is not required.

Recovery equipment certified to J2788 and J2810 does not require this pre-warming procedure.

Removal Procedure

1. **A/C System Controls**
   - ⚠ Compressor clutch off
     - Turn clutch off or remove electrical connection
   - ⚠ Set panel system controls
     - Outside air (not max)
     - High fan speed
     - Airflow panel outlets
     - ATC Systems: Set temperature mid range
       - Check to make sure system is on outside air, drawing air from vehicle cowl air inlet area
2. **Vehicle hood open to allow warm engine air to enter cowl inlet to A/C system**
   - ⚠ Operate engine idle condition
     - Neutral (park) with parking brake applied
     - Depending upon engine compartment temperature:
       - Run engine to warm up A/C system components for 15 minutes
   - ⚠ After idling engine for 15 minutes (hot condition)
     - Stop engine and then turn ignition to on position allowing operation of:
       - A/C fan high; system on Outside air
       - When applicable – Operation of electric engine cooling fan to circulate air in engine compartment
       - Do not change any control or conditions listed in steps 1 and 2 above
       - Start refrigerant recovery process
   - ⚠ When refrigerant recovery is completed, including the required 5 minute recheck for system pressure (system refrigerant out gassing), shut vehicle and equipment off.

To recover as much refrigerant as possible, warm up the system's underhood components with engine and, as already mentioned, apply external heat to the accumulator (if the system has one).

Tests performed for the SAE I-MAC research program indicate that you can remove a higher percentage of the refrigerant by applying heat and performing recovery after the early morning ambient chill has gone.

There are also differences in the percentage of refrigerant that's recovered using best techniques versus shortcuts. A single "pull" on a cool morning might remove 60% of the charge, whereas a careful procedure, using heat to promote outgassing, might remove the over 90% that is necessary for accurate service.

Perhaps nothing can demonstrate the facts better than the data shown in the charts below. They clearly illustrate the vast difference in the amount of refrigerant that can be recovered from a system at different ambient temperatures, and whether or not the system was pre-heated during the recovery process.

Chart A shows that, at 50° F ambient, without pre-heating the system, only slightly more than 70% of the refrigerant is removed on the first recovery attempt. It takes three recovery attempts over 48 hours at this ambient to remove 91.9% of the refrigerant. Pre-heating, even at this 50° F ambient, improves recovery, removing more than 80% of the refrigerant. With pre-heating, a second recovery attempt after 24 hours removes more than 93% of the refrigerant.

Chart B (see next page) shows an increase in the amount of refrigerant recovered at the higher ambient temperature of 70° F; slightly over 80% on the first recovery, compared to just over 70% at 50° F. Pre-heating the A/C system by running the engine further improves the yield, with 87.9% of the refrigerant recovered on the first pull under this condition.

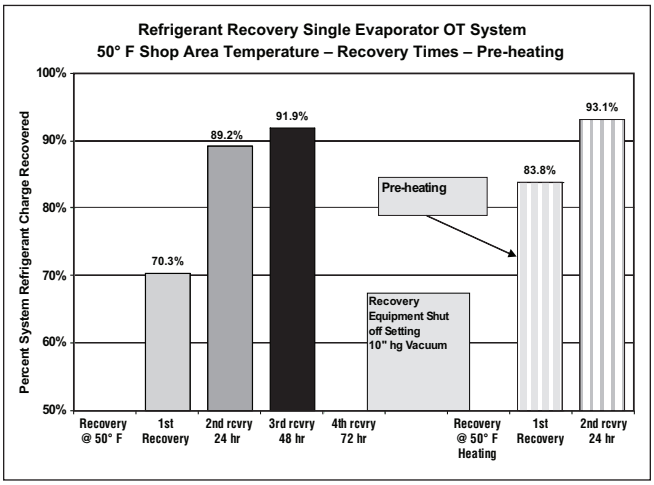

Chart A

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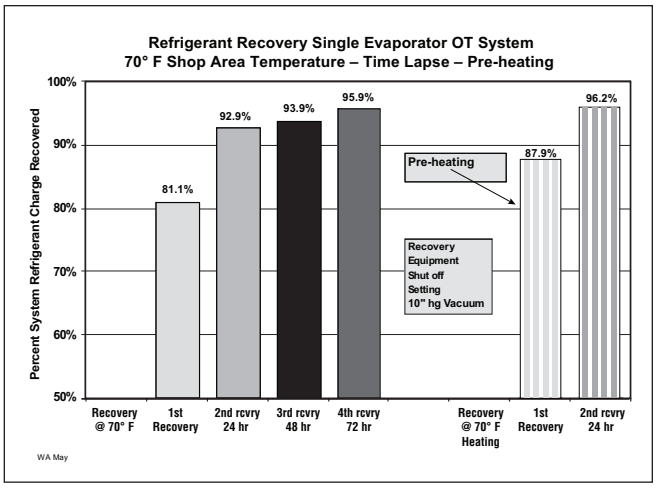

Chart B

Any refrigerant not removed from a system during recovery remains in it and could cause potential problems. If you don't physically apply heat to the system components (especially accumulators) before you start a recovery process, you should first run the engine up to operating temperature, so at least some heat will transfer to the A/C components.

What happens to the refrigerant you didn't get out of the system during recovery?

If the system is opened, the remaining refrigerant will be vented to the atmosphere and you have discarded perfectly good, reusable refrigerant.

If your vacuum pump isn't performing properly – not performing a deep vacuum – or in the interest of saving time – you shortcut performing a deep vacuum, you could end up leaving refrigerant in the system.

If you then recharge the system to specification, you will end up with an overcharge. This costs you money, because you're using more refrigerant than necessary, and the more jobs you do this way, the more money you're losing. However, and possibly even worse, overcharging a system during service can set the stage for future operational problems.

Use of SAE J2788 equipment will assure improved refrigerant recovery during service.

Improperly Recycled Refrigerant

It is important to make sure that recycled refrigerant does not contain air (non-condensable gas) in excess of allowable amounts. If recycled refrigerant contains too much air, high system operating pressure will occur and pressure operated refrigerant controls will have a different control set point. This will result in loss of air conditioning performance and possible system damage.

Properly operating recovery/recycling equipment will remove excess air. Many newer R/R machines have an automatic air purge feature which, if working properly, should assure that its recycled refrigerant will not contain excessive levels of air. However, many older R/R machines require a manual air purge operation.

Make sure you understand which type of air purge feature your machine has and follow its manufacturer's instructions to assure that proper air purging is taking place.

Note: Refrigerant contamination, by air, chemical additives or other refrigerants, can cause system operating problems.

System Lubricants

CFC-12 systems use mineral-based lubricants. HFC-134a systems use several types of polyalkylene glycol (PAG) lubricants.

Different HFC-134a systems require the use of different oils. You must install the type and viscosity recommended by the system or compressor manufacturer. To find out the type you need to use, refer to the underhood A/C system information label, or look it up in a service manual or electronic information system.

To prevent damage to the compressor, it is important that the correct type and viscosity of lubricant (and correct amount of lubricant) is used in an A/C system.

Too little, or the wrong viscosity oil can cause internal compressor failure. But too much oil can also cause problems. Too much oil can cause the compressor to "liquid slug," possibly even hydraulically lock up. Too much oil can also result in reduced overall system performance. The excess oil can heavily coat the interior surfaces of the heat exchangers, insulating the refrigerant from those surfaces.

Do not mix lubricants. Use only the type of lubricant specified by the system manufacturer. The A/C system label will identify the vehicle, compressor or A/C system manufacturer's recommended lubricant, often by an OE part number or designation. However, the label may not list

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the lubricant's viscosity. You may need to consult another source (such as a parts catalog or service information) to obtain the lubricant's viscosity rating.

Recovery-only and recovery/recycling equipment will separate the lubricant during the refrigerant recovery process, so properly recycled refrigerant will not contain too much lubricant.

In general, recovery equipment will remove very little, if any, lubricant from a system. It is a design requirement of the equipment that the amount of lubricant removed during recovery must be measurable. This is usually (but not always) indicated by removed oil being collected in a transparent graduated container.

If a large quantity of lubricant was removed during recovery, the A/C system probably had a lubricant overcharge.

To replace any lubricant removed during a recovery process, use only new lubricant of the type and viscosity specified by the vehicle or compressor manufacturer. Lubricant removed during recovery must not be reused in the system. Used lubricant should be disposed of in accordance with federal, state and local requirements (visit www.ecarcenter.org/ecartour.html for more information on specific disposal requirements).

Here is a typical recovery machine's oil recovery reservoir. It should be emptied before each recovery operation, then checked when recovery is completed to see how much (if any) oil was removed from the system during recovery. If oil was removed, that same quantity of fresh new oil of the type the system requires must be reinstalled in the system before it is put back into operation.

Notes: _____

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Best Service Practices for Mobile A/C System Systems

Sources of Refrigerant Emissions

Motor vehicle air conditioning systems can release refrigerant into the atmosphere in a number of ways:

- Leaks from system part failures and seepage, which occur when a leak is not repaired and the system is recharged or "topped off."
- Refrigerant released during various service procedures.
- Refrigerant released from service equipment, manifold gauges and equipment hoses.
- When using small cans to charge a system, refrigerant remaining in the can is likely to ultimately be vented. The refrigerant remaining in larger (30 pound) disposable containers that has not been recovered is also sometimes vented when they are scrapped.

Checking Mobile A/C Systems for Leaks

The EPA and MACS recommend that leaking systems should be repaired. To pinpoint leaks in mobile A/C systems, MACS recommends using the SAE J1628 service procedure.

Your electronic leak detector(s) must be certified to meet the SAE spec (the detector should be labeled as such), and must be used in accordance with the procedures outlined in the SAE J1628 spec. We've provided an overview of J1628 under "Using Electronic Leak Detectors," and in the sidebar on page 23.

This requires the use of an electronic leak detector certified to SAE standard J1627 or J2791. As minimum criteria, J1627 electronic leak detectors are capable of identifying leakage rates of 0.5 ounces per year at a distance of 1/4 inch from the leak point.

Typical leak detector certification label. It shows that this leak detector meets the minimum performance requirements outlined in SAE standard J1627.

SAE J1627 leak detector manufacturers provide rating information on the detecting capability of their equipment. Detectors which have the most sensitive detection levels will help identify smaller leaks. Manufacturers' service and maintenance procedures must be followed to ensure proper operation of the equipment.

SAE standard J2791, covering HFC-134a electronic leak detectors, requires improved performance compared to J1627 detectors. Detectors certified to this new standard, J2791, have the capability of identifying leakage rates as low as 0.15 ounces per year at a distance of 3/8 inch.

The following charts provide the comparison for different types of leak detection devices and methods.

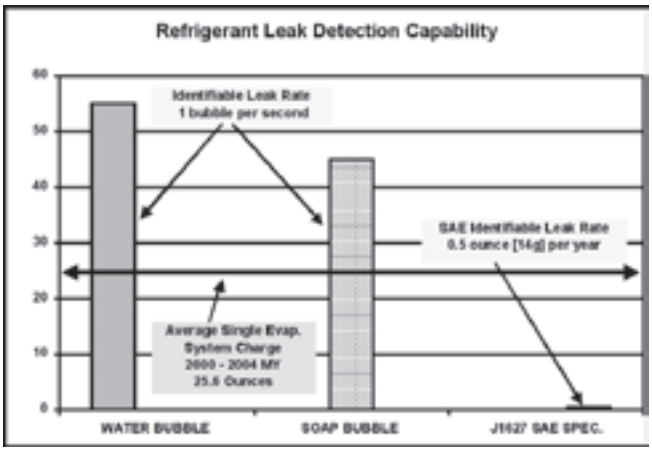

Chart A: This chart demonstrates the effectiveness of various leak detection methods.

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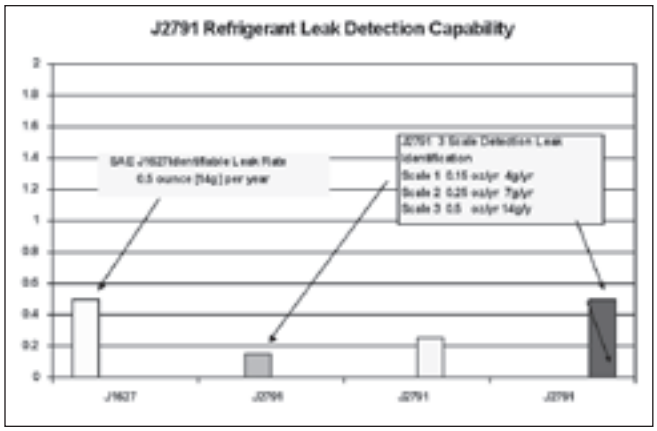

Chart B: This chart compares the effectiveness of SAE J 1627 and J2791 electronic leak detectors.

Using Electronic Leak Detectors

Proper use of leak detection equipment is important since leaks may occur in locations not directly visible. The following procedures are recommended by A/C system manufacturers to best identify system leaks, and are also an overview of the SAE J1628 leak detection procedure.

The system should first be visually inspected by looking for traces of oil on refrigeration system components. Oil traces can be indications of possible leak sites.

The vehicle's engine should not be running during the leak check since air movement from the engine cooling fan(s) can affect the detector's ability to locate leaks. All fittings and components should be checked on all of their surfaces. Leaks can be present at any point, at the top or bottom of the part being checked. (Cleaning the surface with a clean cloth can be helpful. Do NOT use any cleaning solvent!)

To prevent contamination, leak detection must only be done with the refrigerant that is specified for the system. Do not attempt to use shop air for leak detection purposes. Shop air may introduce air, moisture and other contaminants to the system. The use of other gases under high pressure, such as nitrogen, can result in damage to the A/C system (for example, it may cause an evaporator to rupture). Also, since soap bubbles will not detect small leaks, there is no detection equipment to identify a small leak when using air or nitrogen for leak checking.

Also, using another refrigerant (like HCFC-22) could cause chemical damage to system components, such as the desiccant material. Since evacuation of the system may not remove all the HCFC-22, this can further result in seal, hose and lubricant damage.

The SAE J1628 procedure does not require a fully charged A/C system. If the system has only a few ounces of refrigerant and at least 50 psig pressure (at 59° F), that is sufficient to check for a leak. This pressure will be higher with the same amount of refrigerant when the working area temperatures are warmer.

If the system is completely empty, it will be necessary to add some refrigerant to the system in order to use an electronic leak detector. Only a few ounces (about 10 to 15% of the total system charge) is enough to obtain a minimum system pressure.

With this limited amount of refrigerant, you can determine if the system has a leak, but you cannot determine if the system will provide cooling. If you intend to operate the compressor, the system must contain its specified amount of refrigerant.

CAUTION: To prevent possible compressor damage, do not operate the compressor without the full charge of refrigerant as specified by the vehicle manufacturer.

Once the system contains sufficient refrigerant, adding more will not increase pressure. As shown in the curve on the following chart, when the system has about 15% of its total refrigerant charge, a saturated condition occurs, and the pressure will not increase if more refrigerant is charged into the system.

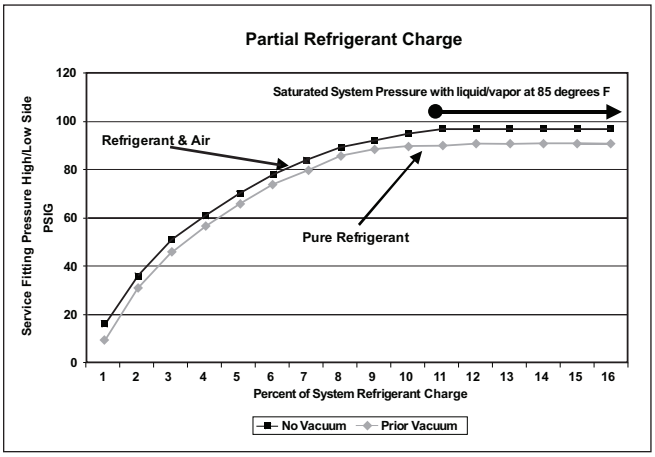

Chart C

The curves found in Chart C also compare a system with a reduced amount of refrigerant with and without air. Without compressor operation, the same pressure will be present in all parts of the system. Since you will not vent refrigerant added for leak testing, the air would be removed when the refrigerant is recovered and recycled.

System pressure also has a direct correlation to the temperature in the work area. With the area having a temperature of 50° F, the pressure will be in the range of 50 psig. It will be about 100 psig at 100° F.

Note: Soap bubbles will only identify leaks that are in excess of 40 ounces per year, compared to the use of a SAE

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J1627 or J2791 electronic leak detector, which can identify leaks with a rate of less than one ounce per year (please refer back to Chart A on page 21).

Another (Big) Reason to Find and Fix Refrigerant Leaks

Loss of refrigerant can reduce oil circulation – even before the low pressure switch or other sensor shuts down power to the compressor clutch. Today's tight-clearance compressors using HFC-134a are tougher to lubricate, even with the right PAG oil. Compressors that are clutch-less can operate until failure of the drive occurs.

If a vehicle comes into your shop with a failed compressor and the system is low on refrigerant, just replacing the compressor is not going to fix the apparent leak. It is important to determine if there were multiple leak sources. Another leaking system part and loss of refrigerant could have caused the compressor failure.

Three Questions about Electronic Leak Detectors

1. What conditions can affect the ability of electronic leak detectors to find leaks?

Dirt and moisture coming in contact with the detector's probe tip can be hindrances when it comes to electronic leak detection. Distance from the probe to the leak site and windy environments also dramatically reduce detectors' abilities to pinpoint leaks.

2. What should a technician look for when purchasing a new electronic leak detector?

Technicians should look at the type of sensor technology used, and whether they are comfortable with the pros and cons of that type. They should also look at sensor life (a typical heated-diode sensor life is 150 hours), detector sensitivity (this should be compliant with SAE J1627, currently 0.5 oz./year for HFC-134a and CFC-12 or J2791 for HFC-134a), power requirements and battery life. Practical considerations like the length and flexibility of the probe in order to get into hard-to-reach places, what type of maintenance the unit requires and the unit's ease of use should also be considered.

3. What is the best way to use an electronic leak detector?

High temperatures increase system pressure and therefore leak rates and actually help to find leaks. Conversely, cold temperatures, especially below 60° F, may reduce pressure/leak rate enough to make it difficult to find leaks.

According to the Interior Climate Control Standards Committee of the Society of Automotive Engineers, the best procedures for using electronic leak detection are detailed in SAE document J1628.

a. The document specifies that the user should perform leak detection in accordance with the equipment manufacturer's operating instructions and with the engine off.

b. In order to get the best performance, the system should be sufficiently charged with refrigerant to maintain at least 50 psi. This may not be possible when the work area temperature falls below 59° F.

c. When working with the detector, care should be taken to not contaminate the detector probe. If cleaning of a part is necessary, do not use cleaners or solvents, which may contain substances that the detector will sense.

d. A visual inspection should be made for signs of lubricant leakage, damage and corrosion, and each damaged area should be inspected with the detector. Other areas to concentrate on are fittings, couplings, controls valves, service port caps, brazed or welded areas and component attachment points. Take care to inspect the entire system so no potential source of leaks will be missed.

e. To obtain the best chance of detecting the leak, move the probe no more than 1-2 inches per second at no more than 1/4-inch from the surface. If you find a potential leak, verify it by blowing shop air around the area and retesting.

f. Leak testing of the evaporator core is a challenging task. This is best accomplished by running the air conditioner blower on high for at least 15 seconds, and then turning the blower off. Wait for refrigerant to accumulate in the evaporator case (the manufacturer of the equipment will specify the time). By inserting the leak detector probe into the blower resistor hole (if near evaporator), condensate drain or other appropriate opening (use the heater or vent duct as a last resort), you should be able to perform a refrigerant leak test.

g. When all service has been completed, leak test the system again to verify a complete repair.

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Using Dye to Find Leaks

Ultraviolet (fluorescent) trace dye systems are a popular choice for techs today in their efforts to hunt down elusive leaks. Not only are they an inexpensive and easy-to-learn method of locating leaks, they also have the advantage of giving the shop visual proof of a leak, which can turn into an interactive experience with the customer.

A typical UV dye leak detection kit contains dye, a dye injector (or some other type of tool to introduce dye to a system), an ultraviolet lamp, and the correct goggles for the dye being used. Always wear the goggles to protect your eyes from the UV light. This kit also contains a special cleaner to remove traces of the dye after the leak is repaired.

Dye Formula

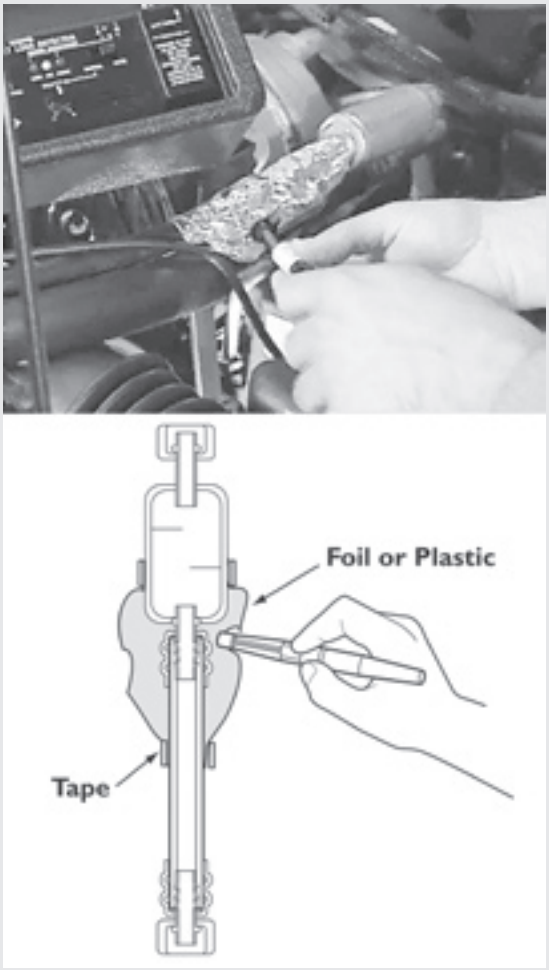
Ultraviolet dye is a microscopic particulate suspended in a base fluid. This base fluid varies from manufacturer to manufacturer. This particulate and base fluid, when introduced into the refrigeration system, mixes with the lubricant and is transported throughout the A/C system. When a leak occurs, this particulate seeps out and leaves a stain on the outside of the component. This stain is then visible when a specific type of UV light is cast upon it.

Dye manufacturers stress that the purity of the dye and its thermal stability is crucial, as the dye will often see A/C system high-side temperatures of over 250° F, then cycle through evaporator at temperatures in the 30° F to 40° F range. The dye should not contain solvents of any kind that could damage system components or diminish the lubricant's properties (including viscosity).

To this effect, the SAE has issued standard J2297 to ensure that dyes are tested for HFC-134a system compatibility, and to make certain that they will not affect lubricant viscosity when used in proper doses. Make sure your dye meets this standard; there are some dyes that don't.

Another Tip on Using Electronic Leak Detectors

To isolate a suspected leak site in an area where air currents could dissipate leaking refrigerant, if possible, tape a piece of aluminum foil or plastic wrap around the connection or component. Allow some time for possible leaking refrigerant to collect in the plastic wrap or foil. Then, make a small hole in the foil or wrap at the lowest area possible and place the leak detector probe at the hole to check for the leak. Lastly, most electronic leak detectors require periodic maintenance to function properly. Refer to your leak detector's instruction manual for more information.



To help confirm a suspected leak, place aluminum foil or plastic wrap and tape it around the connection or component. If there truly is a leak, after a few minutes, refrigerant should accumulate inside the plastic wrap or foil. Make a small hole in the foil or wrap at the lowest point possible and place your leak detector probe at the hole. The detector will indicate "refrigerant found" if a leak is actually present.

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Why is the type of dye important? A dye must be compatible with the system's lubricant - the mineral oil that is used in CFC-12 systems and the PAG oil that is used in HFC-134a systems. While some companies market "universal" dye, no vehicle manufacturer has approved a non-PAG compatible dye for HFC-134a systems. So check that the dye to be used in an HFC-134a system has at least been certified to meet the SAE J2297 requirements.

How Much Dye Is Too Much?

It is important that dyes be safely and properly used. Excessive dye can result in compressor damage. Check with the manufacturer's recommendation, realizing that the amount depends on the dye type, particularly with lubricant-specific dyes. The basic rule of thumb is 1/4 oz. per system.

Lamps & Goggles

Most manufacturers design their UV lamps to work best with their own dyes (so the dye particles fluoresce with their lamp for the best wavelength), and use a reflector and lens to direct and filter the light properly. The UV lamp should also be UL-listed.

The coloration of the special yellow glasses that come with most UV dye leak detection systems enhance the dye's fluorescence and also protect your eyes from UV rays. UV rays are harmful to your eyes, and you should not stare at a UV lamp, just as you would not stare directly at the sun.

Before You Begin Using UV Dye to Find Leaks

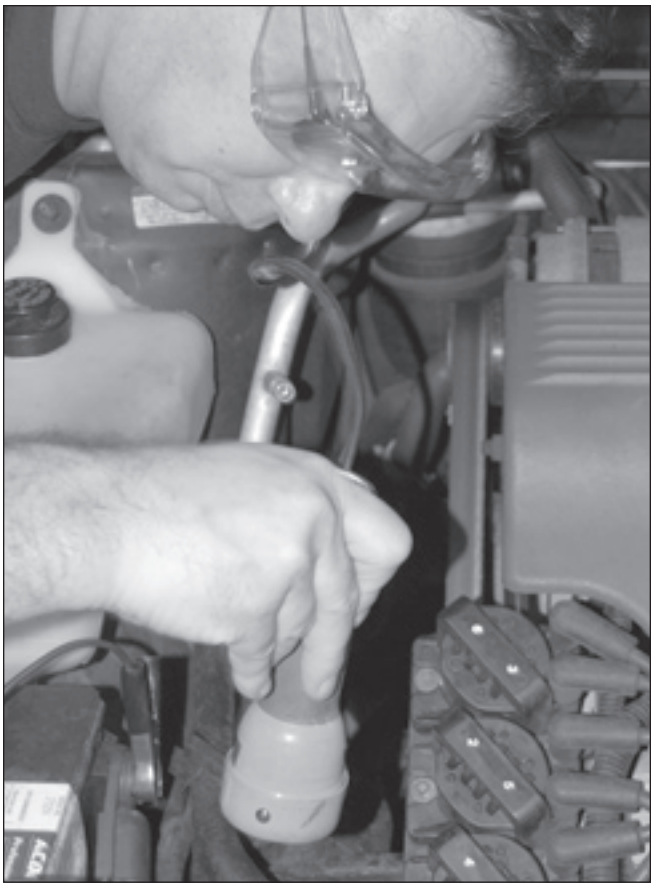
Always start with the dye manufacturer's instructions. They vary slightly, but the process is pretty straightforward. If you are working on a newer vehicle, say five years old or newer, first check to see if there is factory-installed dye in the A/C system. To prevent damage, leak dye should not be added to a system unless the vehicle manufacturer has approved the specific product.

Choosing Your Delivery System

A MACS survey found that techs did not have a consensus on the best way to install dye into A/C systems. It seems that techs are using just about every method, from in-hose dye canisters to caulking gun-type/syringe-type injectors, to simply pouring dye into an open system.

No matter which delivery system you choose, before installing your dye, make sure you have a full refrigerant charge to allow the dye to thoroughly circulate in the system.

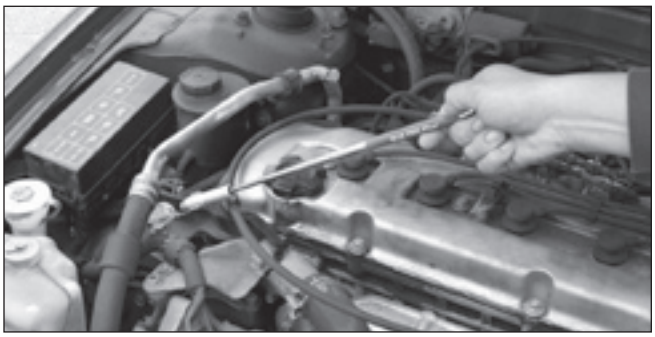
Add the dye, let it circulate. Refrigerant escapes at the leak point as gas, but the dye is brought to the leak site with the lubricant, remaining behind so you can see it glow under a UV lamp.



Like this technician, always be sure to wear the special goggles that came with your UV dye leak detection kit. Not only do they protect your eyes from the UV light, they also make dye traces at leak sites stand out better.

Looking for Leaks

When scanning the system with your lamp, put on the supplied glasses and examine all fittings, lines and components. A helpful trick is to use a mirror to reflect the UV light underneath the components. If you don't have space for a mirror, then use a clean rag to wipe underneath the component and hold the rag under your lamp.



You can use a mirror to reflect the UV light underneath components in hard to see locations. If dye is present at a leak site, you should see it glowing.

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How much time should it take for the leak to appear? Dye makers say that the dye could take anywhere from five minutes to five days to show up at the leak site(s), so don't expect the dye to show up immediately every single time. The length of time depends on the size of the leak.

In cases where a leak does not become readily apparent, you might want to consider installing the dye, instructing the customer to drive the car and use the A/C for a week or so, then bring it back so you can look for visual evidence of leakage. Do not let the customer run the car for months before coming back for their visual inspection and expect to see dye traces. Some of these dyes will wash off or lose their fluorescence over time.

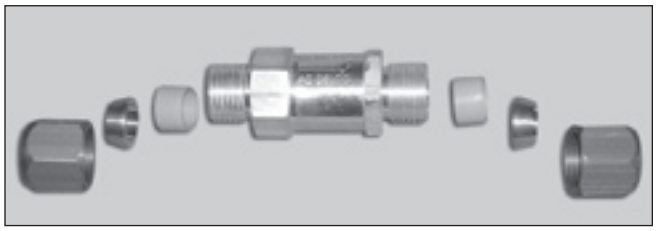
Also keep in mind that with some customers, if you just put in dye and tell them to come back, you can almost bet they won't until the system stops cooling. And by then, the compressor may have taken a beating due to a lack of lubrication from reduced refrigerant flow.

After all system leaks have been identified, and the necessary repairs completed, the system should again be thoroughly leak tested.

You should find that using an electronic detector, along with ultraviolet dye, will often lead to great leak detection results.

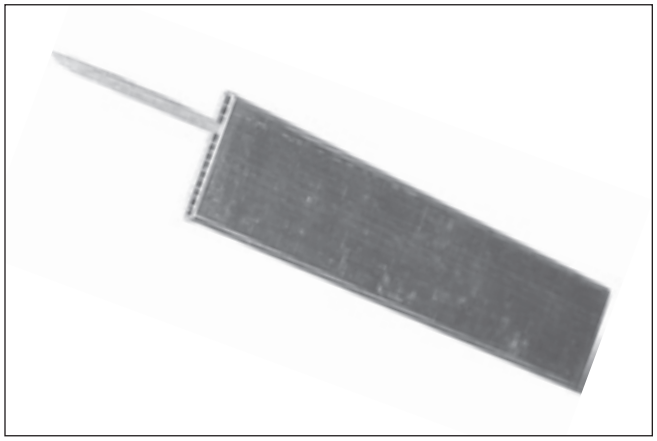
Flushing A/C Systems

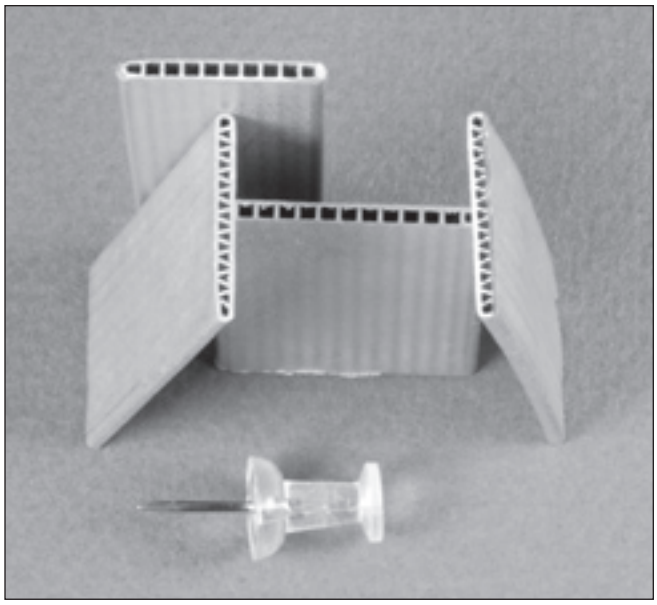
Most A/C system manufacturers recommend that flushing not be performed. Open vent flushing often will not remove debris from a system. Connecting flush equipment to the system service ports, even with the valve cores removed, will not provide adequate system flushing, and may not result in the removal of debris and other substances. Many A/C system manufacturers consider the use of in-line filters to be an effective method of trapping debris.



In-liquid-line filters can be installed to trap debris that may be in an A/C system after it has suffered a catastrophic compressor failure. Filters of this type are available from a number of different A/C parts suppliers.

Many A/C system and component manufacturers also have reservations concerning the use of solvents to flush systems. Other than possible ineffectiveness, the manufacturers' main area of concern is the fact that some solvent may remain in the system, because depending upon a solvent's boiling point, a vacuum pump may not remove all of it, even after a prolonged deep vacuum. This residual solvent can dilute the lubricant, which can lead to inadequate compressor lubrication and possible subsequent compressor failure. It could also possibly affect the chemical stability of the refrigerant, seals and hose materials.





Today's condensers have very tiny refrigerant multi-flow passages. Not only can't you even fully insert a toothpick into some of them, others are so small, a push pin will barely go in. This is why attempts to flush debris-clogged condensers are often not successful.

Flushing compounds that are certified to SAE standard J2670, "Stability and Compatibility Criteria for Additives and Flushing Materials Intended for Use in Vehicle Air conditioning Systems Using HFC-134a," have been tested for compatibility with A/C system components, and found to be compatible. However, this does not assure they will clean the component being flushed (for more information on J2670, and other SAE standards that apply to mobile A/C system service, refer to the appendix on page 48).

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If a flush solvent is used, determine if the solvent is classified as a hazardous material. Dispose of it in accordance with local, state and federal regulations (visit www.ecarcenter.org/ecartour.html for more information on specific disposal requirements).

If you want to power flush a system, a safe alternative to solvent flushing is to liquid flush with the refrigerant type used in the system (some refrigerant recovery/recycling machines provide this feature), being sure to run the discharge refrigerant through an in-line filter before allowing it to enter the recovery/recycling equipment.

Some refrigerant recovery/recycling machines used in conjunction with a flushing adaptor kit, allow you to use liquid refrigerant to closed-loop flush A/C systems.

A/C System Evacuation

Before a system is recharged, it must be evacuated to remove air and refrigerant. It is necessary to use a quality, well-maintained vacuum pump to perform a worthwhile evacuation. But there's a lot more to evacuation than that.

To thoroughly outgas refrigerant, a good vacuum pump, whether stand-alone or built into a recovery/recycling machine, should be capable of drawing the system down to at least 29 inches of vacuum (at facilities located at higher elevations, such as Denver, the gauge reading will be less). A weak or improperly functioning vacuum pump may not be strong enough to achieve complete refrigerant outgassing and removal of air. Incomplete refrigerant removal introduces the potential of overcharging a system, which can result in system performance problems.

To assure proper performance, vacuum pumps must be serviced at the intervals specified by their manufacturers. Vacuum pump service usually consists of not much more than changing the vacuum pump's oil. Typical vacuum pump oil change intervals run from the oil needing to be changed after every 10 hours of pump operation, up to perhaps after every 25 hours of pump operation. Consult your vacuum pump's operational manual to find out how often you need to change its oil.

Experimentation has shown that even when the low-side gauge reads 28 or 29 inches of vacuum, the inside of the system has not actually reached that level of vacuum. The gauge reading more indicates vacuum in the service hose, not in the system.

Consider that the small openings in the service valve cores are major restrictions. It is very difficult to reduce the actual system to 28 or 29 inches of vacuum, and even with a very good vacuum pump, it can take a long time. Therefore, manufacturers suggest evacuation times of 30 to 45 minutes to assure that an adequate evacuation has been performed.

When it comes to removing moisture, the entire system, not just the service gauge reading, must be below 29 inches of vacuum. Actual moisture removal does not start until the system has been reduced to at least 29.25 inches of vacuum.

Water boils at 212° F at sea level. By reducing the actual system pressure to 27 inches of vacuum, to accomplish moisture removal, the entire system would have to be raised to a temperature of 115° F.

So the bottom line is, even the best vacuum pump or recovery/recycling machine may not remove moisture by evacuation. The best assurance for control of excess mois-

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The only way to remove significant moisture from a system is to replace the receiver drier or accumulator. Not only that, most compressor supplier's warranties require that the R/D or A/D be replaced when one of their compressors is being installed.

ture in the A/C system is to install a new receiver/drier or accumulator with fresh desiccant.

Desiccant Failure

While we're on the subject of desiccant; blend refrigerants that contain HCFC-22 require XH9 desiccant, which is generally not available to the mobile A/C service industry. If HCFC-22 is charged into a mobile A/C system, desiccant damage could occur. This can cause blockages within the system.

Some EPA SNAP-accepted substitutes might contain refrigerant(s) (such as HCFC-22) incompatible with the desiccants used in HFC-134a or CFC-12 systems (for more information on EPA SNAP-accepted alternate refrigerants, please refer to pages 42 - 45).

When the refrigerant fittings (lines and components) are left un-capped and open to the atmosphere for an extended period of time, moisture can enter the system and result in the desiccant becoming saturated. It is advisable to keep the refrigerant circuit connections closed. If left open for a period longer than normal servicing activity, the desiccant should be replaced to provide moisture control. Systems left unsealed during vehicle collision repairs can result in moisture entry.

Properly Charging (and Recharging) Mobile A/C Systems

To reduce refrigerant emissions, newer mobile A/C systems use less refrigerant. Because of this, today's newest systems are "critical charge." A critical charge system is one that is substantially less tolerant to variations in charge.

Undercharges can result in poor cooling, and even worse, poor lubricant circulation, which can lead to compressor failures. Overcharges can result in high operating pressures, which can also cause poor cooling performance, and even component damage. During hot weather conditions, overcharged systems can experience system shutdown from the high side pressure control switch due to high system pressure. Because of this, mobile A/C systems should only be charged with known amounts (by weight) of refrigerant. The customary "top-off" method is no longer acceptable.

Compounding the problem is that some charge equipment considered good a few years ago cannot provide the accuracy you need for late-model systems. For example, BMW and MINI specify a charge tolerance of just plus/minus 10 grams (1/3-oz).

Show Me the Data

A typical CFC-12 system required a 3 lb. refrigerant charge, but the first HFC-134a systems required only about 1.9 lbs. By model year 2000, the industry average charge for a single evaporator system was 1.6 lbs., and in model year 2004, the average charge was down to 1.5 lbs. As charge volumes have dropped, system's tolerances for too much or too little refrigerant have changed as well.

A system with an incorrect refrigerant charge may suffer unseen problems. Low charge can result in uneven temperatures at the panel outlets and localized evaporator freezing, which can reduce system airflow. Reduced cooling can also occur due to a lack of liquid refrigerant entering the evaporator. Under high cooling loads, a portion of the refrigerant may enter the evaporator as a vapor, reducing system efficiency.

Test Data

Vehicle manufacturers determine refrigerant charge amount by running a specific test under high-load conditions in a climatic test chamber. They must consider several factors, including accurately measuring the charge amount, allowance for some reserve in the system and the effect of too much refrigerant causing a system shutdown via the high-pressure compressor clutch cutout switch.

Table 1 and Chart D (on the next page) show information on factory charge tests for three different types of refrigerant systems on different vehicle platforms. These tests were performed at 100° F, and cover refrigerant charges ranging from 16 to 30 ounces. The factory-specified refrigerant charge is 22.4 ounces for the integral condenser/receiver/drier (IRD) system, 28 ounces for the expansion valve (TXV) system and 26 ounces for the orifice tube (OT) accumulator system.

In Table 1, notice how little the pressure changes in some systems as the refrigerant charge diminishes below the factory charge amount. For example, on the TXV system, a 20

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Table 1 – System Charge

System Charge Oz.	16	17.6	18	19.2	20	20.8	22	22.4	24	26	28	30
Int RD												
High Side PSIG	201	223	230	233	235	237	238	239	239			
Low Side PSIG	29.3	31.4	31.7	32	31	31.9	31	31.9	31.8			
Panel Outlet Degrees F	59.3	55.2	54	54.3	54	54.1	54	53.9	54.1			
TXV												
High Side PSIG	225	235	240	250	260	280	295	295	295	295	300	310
Low Side PSIG	15	16	18	20	22	23	24	23	22	24	26	28
Panel Outlet Degrees F	78	75	70	68	65	63	61	61	61	60	60	58
OT												
High Side PSIG	198	203	207	210	216	220	225	230	233	239	248	
Low Side PSIG	28	29	30	31	32	33	34	36	37	38	40	
Panel Outlet Degrees F	56	56	56	57	58	58	58	59	60	62	63	

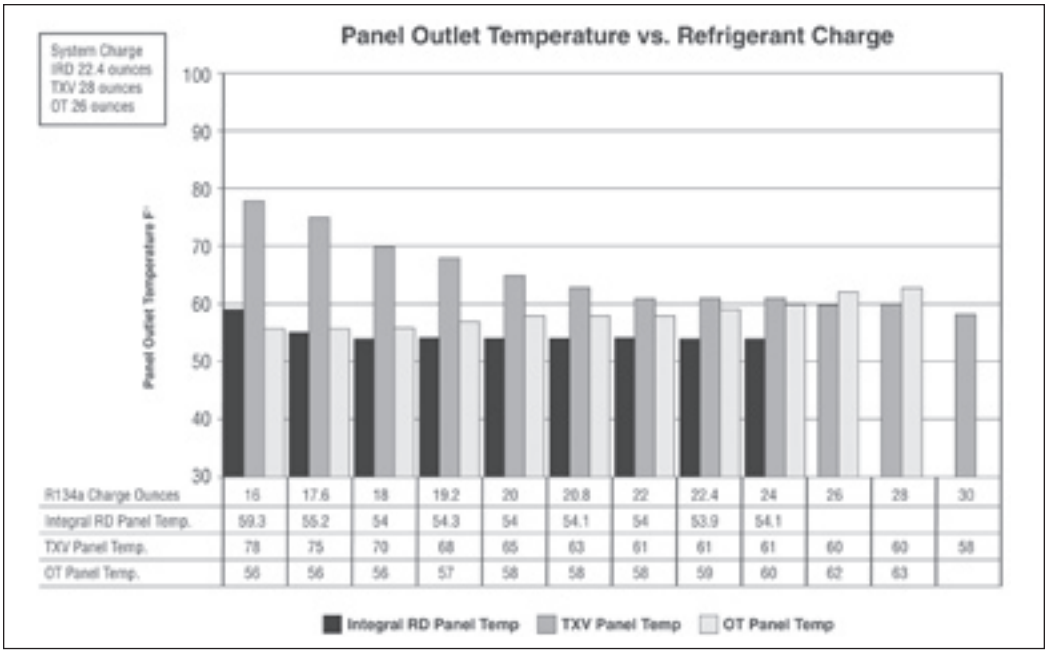
Panel Outlet Temperature vs. Refrigerant Charge
System Charge
IRD 22.4 ounces
TXV 28 ounces
OT 26 ounces
Panel Outlet Temperature F
100
90
80
70
60
50
40
30
R134a Charge Ounces 16 17.6 18 19.2 20 20.8 22 22.4 24 26 28 30
Integral RD Panel Temp. 59.3 55.2 54 54.3 54 54.1 54 53.9 54.1
TXV Panel Temp. 78 75 70 68 65 63 61 61 61 60 60 58
OT Panel Temp. 56 56 56 57 58 58 58 59 60 62 63
Integral RD Panel Temp
TXV Panel Temp
OT Panel Temp

Chart D

percent reduction in refrigerant charge (from 28 oz. to 22.4 oz.) resulted in the high side pressure dropping only 4 psig, from 300 to 295. On the IRD system, a loss of 20 percent of the charge resulted in the low side pressure dropping only two-tenths of a pound, from 31.8 psig to 32 psig. It is obvious that pressure changes resulting from reduced charge can be very small and may not be reliably indicated by pressure gauge readings. Further, the data in these charts was obtained using laboratory instrumentation. Attempting to identify these small pressure changes using a service manifold gauge set to charge the system is not realistic.

It's also plain that pressure changes are not linear to the amount of refrigerant in the system. A system may be 10 or 20 percent under the desired refrigerant charge amount and still show apparently near-normal pressure gauge readings. Measuring high and low side pressures will not provide any indication concerning the amount of refrigerant in a system.

Use Chart D to see the effect of reduced refrigerant charge on panel outlet temperatures. Again, the changes are small and sometimes surprising. At 20 percent below the specified charge, except for the OT system, the same approximate outlet temperature was achieved. Measuring outlet temperature will not provide any indication of the amount of refrigerant in a system.

Lubricant circulation in the system relies upon a proper refrigerant charge, and inadequate refrigerant (and therefore lubricant) flow in the refrigerant circuit will result in increased compressor operating temperature. These higher operating temperatures can result in damage to the compressor, lubricant, and flexible hoses and seals.

Table 1 (above) and Chart E (on the next page) compare the effect of reduced refrigerant charge on system pressure in three types of single evaporator systems. For the Integral Condenser/RD, the high pressure change from

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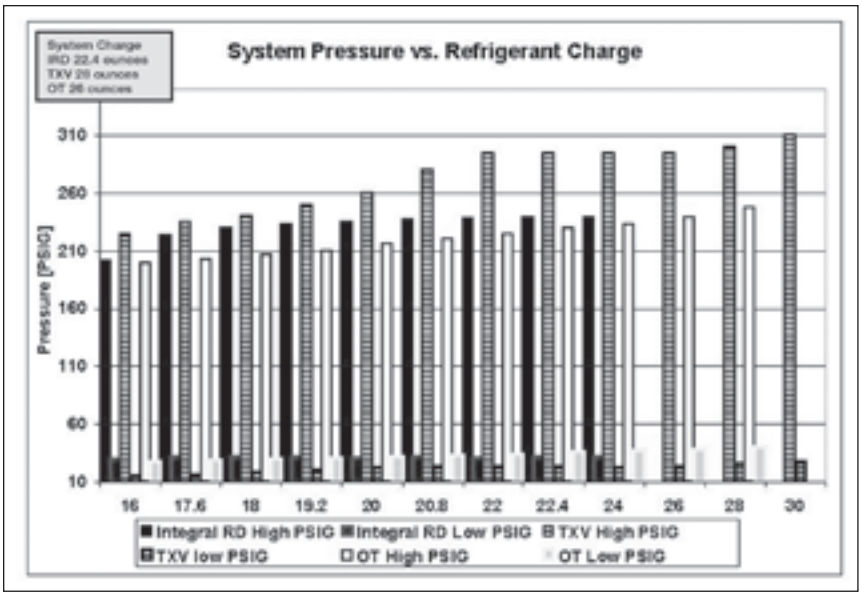

Chart E

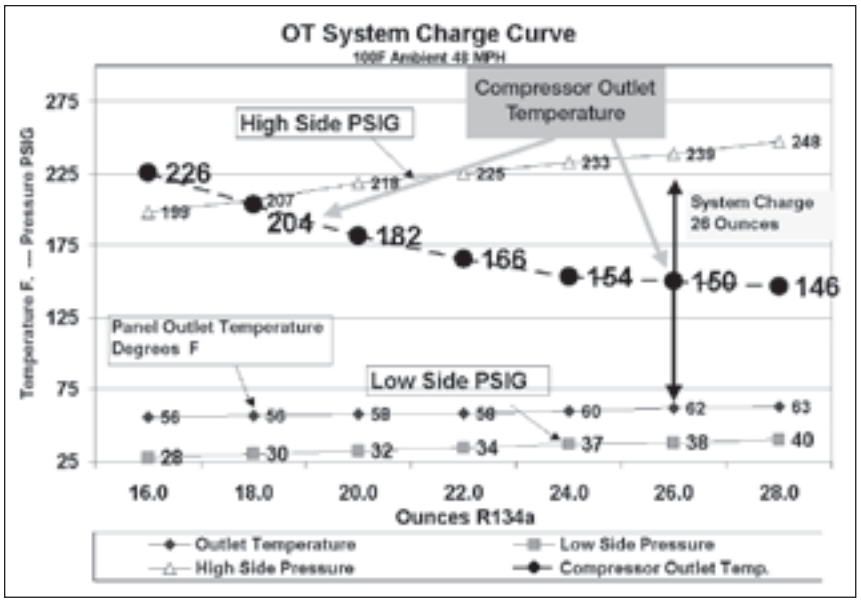

Chart F

18 to 24 ounces (6 ounce change) is only 9 psig (230-239) and low side is less than 1 psig. The TXV system pressure change on the high side from 24 to 30 ounces (6 ounce change) is 15 psig (295-310) and low side is 3 psig (61-58). The OT system pressure change on the high side from 22 to 28 ounces (6 ounce change) is 23 psig (225-248) and low side is 5 psig (58-63).

Chart F shows the effect of reduced refrigerant charge on the compressor discharge temperature of a factory specification 26-ounce orifice tube system. The undetectable problem is the compressor outlet temperature change, and this is not identifiable by just looking at the system pressures. When the refrigerant charge is reduced by twenty percent (to 20.8 oz), compressor outlet temperature increased from 150° F to 182° F. Increased system operating temperatures reduce durability.

This industry data proves several points. To provide your customer true professional service, don't attempt to establish system refrigerant charge using pressure readings or by using top-off procedures. If you have any question about the amount of refrigerant in a system, remove the charge, evacuate the system, and install the correct amount. It's the only way to do it right.

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INCORRECT SYSTEM CHARGES - SOME REASONS WHY

Following are several more reasons that A/C systems end up getting charged with the incorrect amount of refrigerant.

Making an Unintentional Mistake While Determining the Charge Amount

One reason for incorrect charge is making an unintentional mistake while determining the recharge amount. We sometimes see this because a vehicle manufacturer may find out long after a vehicle hits the street that they can get better A/C performance by increasing or reducing the system's charge. Or, there may have been a late change in a component that changes the charge spec, and that change was not made on the production line or on the vehicle's A/C system information label. So unless you have access to the latest service bulletins, you may not know about it.

Sometimes, new refrigerant labels are released. However, the odds that a new refrigerant label was actually attached to the vehicle are pretty remote, so checking for bulletins is important, including those for the not-so-new models that you're likely to be working on. Please keep in mind that the original charge was approved after testing, so if there's a new charge specification, it may not improve cooling under all conditions.

Also, some replacement condensers require a change in system charge spec, usually a reduction. These units are accompanied by instructions stating the new spec, as well as a new label that you are directed to place over the vehicle's original charge spec label. But does every tech always read all of the instructions that come in a box with a part? And even if so, once again, will every tech be diligent enough to affix the new label to the system? Always be on the lookout for these types of "outside the box" circumstances.

Incorrect Calculation of Charge

Probably the easiest error to make is calculating pounds to ounces when there's a decimal involved. Here's a case history from a '93 Chrysler minivan with a 3.13 lb. spec. An inexperienced tech charged 3 lbs., 13 ounces (3 lbs. x 16 for a total of 48 ounces, plus 13 equals 61 ounces) into the system. The correct amount is 50 ounces (0.13 lb. x 16 ounces is 2.08 ounces. Add in 48 ounces - 3 lbs. x 16 - and the total is 50.08 ounces). So the results were about an 11 ounce overcharge, high discharge pressures and a puzzled technician.

Or the reverse could apply: A label in ounces and a machine with a display in pounds (with the decimal). In this case, divide the total number of ounces by 16. Example: 50 divided by 16 equals 3.13 lbs. If your machine display is calibrated to a single decimal place, round off 3.13 lbs. to 3.2 lbs.

This machine is displaying the refrigerant charge amount in pounds and ounces. Unfortunately, the label on every vehicle you service won't list the spec this way, so calculations will be needed; an easy place to make a mistake. (Some machines allow you to change the display units, but how many techs do so every time they can or should?).

Still another calculation issue: grams and kilograms when you have a machine in pounds and/or ounces. There are 28.4 grams per ounce, and 2.2046 pounds per kilogram. The numbers are usually rounded off on spec labels, and if so, you won't have to worry about that level of accuracy.

Land Rover labels are very good, in that they give grams and ounces, and make it clear which specification applies to a front-only and also which apply to front/rear systems.

These refrigerant labels are typical of those used on two different Land Rover vehicles. They give the refrigerant capacity in grams and ounces for both front-only systems (half-vehicle silhouette) and front-rear systems (full-vehicle silhouette), and the plus/minus tolerance both in grams and ounces. Notice that the one (for a larger system) has a plus/minus tolerance of 50 g (grams), whereas the other (for a smaller system) has a tolerance of 25 g. Many specifications use 25 or 50 g, instead of the more precise 28.4 grams per ounce, for the plus/minus tolerance.

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If you're working in ounces, the bottom label's front system would get a charge in the range of 30-34 ounces.

Volkswagen uses grams, so if you're converting to ounces, divide by 28.4. Example: 750 grams equals 26.4 ounces (just under 26-1/2 ounces) and the tolerance is plus (no minus) 50 grams, which equals 1.76 ounces (just over 1-3/4 ounces). So the precise range is 26.4 to 28.16 ounces, although it's apparent VW is using 25 grams per ounce and 50 grams as equal to two ounces for the plus tolerance. So adding two full ounces to the base (converted) specification of 26.4 ounces would be logical in this case – although at 28.4 it wouldn't round up to 29 ounces. It means you have to charge the system with 27-28 ounces. Note: DO NOT assume that 25 grams is an acceptable conversion value to ounces for the ENTIRE charge, only for the tolerance. If your machine is calibrated in pounds, use the low and high numbers divided by 16 to get the range: 26.4 to 28.4 ounces equals 1.65 to 1.78 lbs. (round up to 1.7 to 1.8 lbs.). If the machine is calibrated in kilograms, just divide the numbers at each end of the range (700-800 grams) by 1000 to get kilograms, and that would be 0.7 to 0.8 kg.

This Volkswagen label gives refrigerant capacity in grams, along with the plus tolerance (notice there's no minus, so the range is 750-800). In this case (although ounces are not listed), the specification tolerance of 50 grams can be rounded off to two ounces in any conversion.

Nissan uses pounds and kilograms, and if your machine is calibrated in pounds, please notice that the plus/minus tolerance is just 0.055 lb., which is 0.88 ounces, less than the 0.1 lb. on most decimal scales. Here again, take the range and aim for something within it. The specified charge is 1.21 lbs., so the range is 1.155 to 1.265 lbs. or 18.48 to 20.24 ounces.

Nissan is not totally consistent, at least not between the Nissan Maxima and the Infiniti M45 models. No tolerance is specified for Infiniti, just a single number.

AIR CONDITIONER NISSAN
REFRIGERANT
COMPRESSOR LUBRICANT
TYPE (PART NO.)
HFC 134a (R134a)
NISSAN LUMINOUS OIL TYPE DH-PS (KLH00-PAGS0)
AMOUNT
0.55 ± .025 kg (1.21 ± 0.055 lbs)
150 ml (5.03 oz.)
CAUTION
PRECAUTION
• REFRIGERANT UNDER HIGH PRESSURE.
• SYSTEM TO BE SERVICED BY QUALIFIED PERSONNEL.
• IMPROPER SERVICE METHODS MAY CAUSE PERSONAL INJURY.
• CONSULT SERVICE MANUAL.
• THIS AIR CONDITIONER SYSTEM COMPLIES WITH SAE J-639.

Nissan (Maxima) label shows refrigerant capacity in pounds and kilograms, to two decimal places, and a tolerance to three decimal places.

Infiniti (MX45) label shows refrigerant capacity in pounds and kilograms, but with no tolerance listed.

The bottom line is that it's a good rule of thumb to have a combination of equipment, and to work out a method that will always enable you to be able to charge within 5% of the specs. If you have to convert between metric and English, don't try to do it in your head or even with pen and paper. Small calculators are cheap, you probably have a few in your shop now, and you can tape a conversion chart to the underside for easy reference.

Conversion Chart

Ounces (oz) to pounds (lbs.): divide by 16
Pounds to ounces: multiply by 16
Ounces to grams (g): multiply by 28.4
Grams to ounces: divide by 28.4
Pounds to kilograms (kg): divide by 2.205
Kilograms to pounds: multiply by 2.205
Kilograms to ounces: multiply by 35.27
Ounces to kilograms: multiply by 0.0284

Don't guess at U.S. to metric conversions. Use a calculator with this conversion chart (or an equivalent) for easy reference. And watch those decimal points.

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Equipment Inaccuracy

The accuracy of shop equipment is a major issue.

- You might have an old recovery/recycling/recharge machine with a digital scale. Its accuracy was never great in its best days. For example, the GM ACR-4, the first dealer recovery/recycling/recharge machine for HFC-134a systems, had a built-in tolerance that was later discovered could go as high as plus/minus six ounces – a 19% variation in a two-pound system. At one time, that might have been close to acceptable. But since system capacities have dropped, and tolerances with them, you can encounter a performance problem if you're more than 5% off.
- That digital scale, after years of use with little or no maintenance (and probably some abuse) is likely to have become inaccurate. Just because it's calibrated to one ounce or 0.1 lb. does not mean it's accurate to within one ounce or 1.6 ounces. There may be a big difference between the resolution of the digital display and the actual accuracy of the machine in delivering a charge.
- Some machines have a calibration feature for the scale with special weights, but if nothing else, you can put 33 pennies on top of the jug and see if the scale can tell the difference. 11 pennies weigh one ounce, so with 33, there should be an increase in weight of at least 0.1 lb or two ounces, up to 0.2 lb. or three ounces.

New recovery/recycling/charging equipment meeting SAE J2788 certification will provide more accurate refrigerant removal and charging measurements, and provide a method for calibration of the scale.

33 pennies weigh three ounces, and most shops can come up with them. They can be used to check the scale on your recharge machine. Place them on top of the refrigerant tank, and check the scale reading on the machine's readout. If the scale is working properly (within tolerance), the scale reading should show an increase in weight of at least 0.1 lb or two ounces, up to 0.2 lb. or three ounces. If this does not happen, the scale needs either calibration or replacement. Anything else is not accurate enough for charging today's tight tolerance systems.

As you can see, the scale on this recovery/recycling/recharge machine is dead on. With 33 pennies placed on top of its refrigerant tank, its readout shows an increase in weight from 34 lbs., 4 oz. to 34 lbs., 7 oz.

SAE had not established any requirements covering the accurate measurement of recovered and charged refrigerant when servicing mobile air conditioning systems prior to SAE J2788. During industry studies it was determined that an accuracy problem can exist when transferring refrigerant during service. The study revealed that electronic readouts may give incorrect readings during service. Examples of readings compared to actual amount of refrigerant transferred in vapor and liquid form can be found in Table 2.

TABLE 2 – Refrigerant Transferred Reading vs. Actual Amount

Refrigerant Phase	*Equipment Reading Oz.*	*Actual Refrigerant Amount Transferred Oz.*	*Diff. From Actual Oz.*
Vapor	*8*	*30.3*	*22.3*
Vapor	*31*	*32.4*	*1.4*
Vapor	*2*	*12.4*	*10.7*
Liquid	*50*	*47.3*	*-6.3*
Liquid	*36*	*52.7*	*16.7*

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The only service equipment that meets the SAE requirements for charging and removal of refrigerant from a system carries a certification to SAE J2788.

With the requirement to service reduced refrigerant charge systems, SAE J2788 equipment provides the following measurement accuracy:

- The equipment must be capable of both indicating and recharging the system to within 15 g (0.50 oz) of vehicle manufacturer's specifications.
- If a scale is used in the machine, the equipment manufacturer shall provide a method or service for the technician to check scale accuracy, and include any necessary accuracy-checking device (such as a calibration weight(s)) with the machine.

If you are having a problem with system performance or high system operating pressure you may want to check if the charging equipment is transferring the correct amount of refrigerant.

Test Procedure for Refrigerant Transfer

Using a separate container and an external calibrated scale:

1. Evacuate and weigh the container on the calibrated scale and record the container weight.
2. Transfer an amount of refrigerant from the charging equipment.
3. Check the container weight and determine if the weight has increased by the amount you transferred from the charging equipment.
   - If the container weight (step 1) has not increased by the amount transferred (step 2) then the measuring device on the charging equipment may be in error.

Not Accounting for the Refrigerant Inside the Service Hoses

Charge the system with the specified amount of refrigerant, allowing for the capacity of the charging hoses. A typical six-foot service hose holds approximately two ounces of refrigerant. The use of very long service hoses can cause a system to receive an overcharge if procedures are not followed that take hose length into consideration. Some charging equipment is programmable to allow for different hose lengths, which should assure an accurate charge. Refer to your machine's instruction manual for more information.

Technician Doesn't Accept the Specs

It's amazing how many shops refuse to accept the factory spec, even if there's no bulletin to the contrary. Or somehow, they have acquired this idea that a little more refrigerant should be helpful. So they add refrigerant. If they're unlucky, along with something else they do, or a part they replace, the system cools better – in the shop – than when it came in. Why is that unlucky? Because when it's really hot and the car is slow-moving in traffic, the high side pressure goes way up and the system shuts down. Then maybe some other shop gets the job, does an evacuation and recharge, and enjoys a "phantom repair" at the expense of the first shop's reputation.

Charging Systems with Small Cans or by Attempting to Use Pressure Readings

Part of this one's already been mentioned, but If you're charging with small cans, or even using 30 pound cylinders, but trying to charge a system going by gauge readings, or using any other method that does not involve accurately weighing the amount of refrigerant entering the system, **STOP!**

Pressure gauges are a diagnostic tool, but you can't use them to meter refrigerant into a system, and no vehicle or system manufacturer provides exact pressure specs for a precise charge. Even if you have reliable pressure readings, as we've already pointed out, there isn't enough of a pressure difference to indicate over or undercharge.

System pressure readings, whether the system is operating or off, will not identify the amount of refrigerant in a system. The only way to assure that any given system's refrigerant charge is correct is to recover all of the existing refrigerant, perform a thorough evacuation and install a known amount. If you have a recovery/recycling only machine, consider purchasing an accurate digital scale, perhaps one with a solenoid-type dispensing valve.

Some technicians still attempt to use small cans and pressure gauge readings to charge systems, but accurate charging is not possible with this method.

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More on Refrigerants and the Proper Use of Refrigerants

Whenever you hear the term "refrigerant contamination," the first thing you probably think of is mixed refrigerants. However, the most prevalent contaminant, particularly in recycled refrigerant, is air.

This section will provide tips on dealing with both of these problems; excessive amounts of air in refrigerant and cross-contaminated refrigerant.

Three Questions on Air-contaminated Refrigerant

1. What problems are caused by excess air in a vehicle air conditioning system?

Air, in excess of allowable amounts, can cause the system to operate at pressures that are higher than normal. This can result in noisy system operation and loss of air conditioning performance. (Air is not a good heat transfer medium, as is refrigerant, and higher pressures also mean higher condenser temperatures, which can also degrade system performance.) It can also cause the system's high pressure compressor clutch cut out switch to inhibit compressor clutch operation, and/or, depending on the circumstance, possibly cause damage to system components due to overpressure conditions. In systems that use the low side pressure to control the evaporator (such as pressure cycling or variable displacement compressors) a system having excess air in the refrigerant will have a loss of performance.

Generally speaking, having more than about 2% air (by weight) in the refrigerant charge can start to cause problems with system operation. With some systems, every percentage point that air contamination exceeds 2% can lead to a one degree F increase in evaporator outlet temperature. For example, a system containing 10% air may be blowing eight degrees warmer than it should at the dash outlets, even if everything else in the system is functioning perfectly.

The bottom line is that the maximum acceptable amount of air contamination is generally considered to be no more than 2%.

2. How can technicians determine if refrigerant contains too much air?

The only way to determine the amount of air contained in refrigerant is to use a refrigerant identifier. To determine if a container of refrigerant has excess air, the following approach can be used.

- *The container must be kept at a stable temperature for several hours before taking the readings. In a busy shop atmosphere, this is not always possible.*
- *Contamination can also be caused by mixed refrigerants which can produce readings similar to those in the charts on page 36, mimicking air contamination. In other words, the pressure/temperature method cannot identify whether the higher readings are being caused by air in the refrigerant, or if they are being caused due to refrigerant cross-contamination.*

Pressure/Temperature Method for Determining the Amount of Air Contained Within Refrigerant in a Container

To determine if a tank of recycled refrigerant contains an excessive amount of air, the tank must be stored at a temperature of at least 65° F for a period of 12 hours, protected from direct sunlight. It is also advisable not to store tanks directly on the cement shop floor since the floor temperature can affect the tank temperature. Placing some form of insulation, such as a piece of wood between the tank and the floor will help stabilize the tank pressure. If these conditions have been met, a check for air may be performed as follows:

- *Install a calibrated pressure gauge to the refrigerant container. The gauge should be graduated in 1 psi divisions.*

This is a typical tank pressure gauge on a recovery/recycling machine. Its reading, with the ambient temperature reading and Tables 3 and 4 (on page 36), can be used to determine if excess air is in the refrigerant storage tank. If the pressure reading is too high, air must be purged from the tank until the gauge reading matches the proper one listed in the table. Still, a refrigerant identifier is the best tool to use to obtain a reading on the amount of air that might be in recycled refrigerant.

- *To measure the refrigerant liquid temperature, attach a calibrated thermometer to, and measure the temperature of, the lower one-half of the refrigerant container's outer surface. Or, "shoot" an infrared thermometer at the lower one-half of the refrigerant container to obtain a reading. Using only the air temperature reading in the vicinity of the refrigerant container can result in incorrect refrigerant temperature information.*

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- *Compare the pressure gauge and temperature readings with the limits found in Tables 3 and 4. Use the figures in Table 3 for CFC-12, and the figures in Table 4 for HFC-134a.*
- *If tank pressure is below the figure listed in the table, and the refrigerant has been recycled, the refrigerant does not contain an excessive amount of air. If tank pressure is higher than that listed in the table for the ambient temperature, and its contents have been recycled, it is advisable to use a refrigerant identifier and confirm if the high pressure is due to excess air or cross-contamination. If it's determined to be excess air, **slowly** vent (purge) the air from the tank. Continue purging until tank pressure is below that shown in the table. As the purge process is performed, the container will cool and the tank pressure will decrease. Allow the temperature to stabilize then re-perform the check to confirm if there is still excess air remaining in the tank.*

***Remember:** The information in the tables is only reliable if the tank has been kept at a stable temperature for several hours before the readings are taken, has been kept out of direct sunlight, contains some liquid refrigerant, and no refrigerant*

You can use the recovery/recycling/recharge machine's air purge valve to purge excess air from recycled refrigerant. Let the air out, and watch the pressure gauge on the machine's panel. When the gauge reading reaches the appropriate number in the table (based on the ambient temperature), close the purge valve. The recycled refrigerant now does not contain an excessive amount of air, and can be reused to recharge an A/C system.

TABLE 3 - Maximum Allowable Container Pressure – Recycled CFC-12

Temp º F	PSI	Temp º F	PSI	Temp º F	PSI	Temp º F	PSI	Temp º F	PSI
65	74	75	87	85	102	95	118	105	136
66	75	76	88	86	103	96	120	106	138
67	76	77	90	87	105	97	122	107	140
68	78	78	92	88	107	98	124	108	142
69	79	79	94	89	108	99	125	109	144
70	80	80	96	90	110	100	127	110	146
71	82	81	98	91	111	101	129	111	148
72	83	82	99	92	113	102	130	112	150
73	84	83	100	93	115	103	132	113	152
74	86	84	101	94	116	104	134	114	154

TABLE 4 - Maximum Allowable Container Pressure – Recycled HFC-134a

Temp º F	PSI	Temp º F	PSI	Temp º F	PSI	Temp º F	PSI	Temp º F	PSI
65	69	75	83	85	100	95	118	105	139
66	70	76	85	86	102	96	120	106	142
67	71	77	86	87	103	97	122	107	144
68	73	78	88	88	105	98	125	108	146
69	74	79	90	89	107	99	127	109	149
70	76	80	91	90	109	100	129	110	151
71	77	81	93	91	111	101	131	111	153
72	79	82	95	92	113	102	133	112	156
73	80	83	96	93	115	103	135	113	158
74	82	84	98	94	117	104	137	114	160

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cross-contamination exists. It is also important that during the purge process, the tank does not become cold, since a cold tank of refrigerant will reflect an incorrect pressure reading. Also keep in mind that while pressures higher than those in the charts indicate contamination, they do not indicate the type of contamination (is it air, mixed refrigerants, or a combination of both?).

If tank pressure exceeds the limits in the tables, and you are sure that no cross-contamination exists, the refrigerant can be recycled and reused. Just be sure to re-perform the check for air process before charging the refrigerant into a system.

This procedure cannot be used to determine if a mobile A/C system has contamination from air or mixed refrigerant.

3. What can I do to address the problem of air in, and getting in, my refrigerant supply? How do I remove excess air from an A/C system?

Air can be introduced into the refrigerant supply when refrigerant is recovered if there are any leaks in the A/C system or the service hoses. Inspection of service equipment hoses and connections is important to assure that they are not a leak source.

The A/C system must be checked for leaks using approved leak detection equipment and methods. After performing refrigerant identification, the refrigerant must be recovered from the system using approved and properly maintained refrigerant recovery/recovery/recycling equipment. All system leaks (if any) must be repaired. After all refrigeration system service is completed, the system must be properly evacuated (to a deep vacuum) to ensure that all air is removed. Short cutting evacuation or failing to purge air from the recovered/recycled refrigerant are two of the most common causes for air to exist in refrigerant and A/C systems. Others are improperly operating or maintained recovery/recovery/recycling equipment, and vacuum pumps in need of oil changes and/or other maintenance.

Properly operating recycling equipment, used in accordance with its manufacturer's instructions, will remove excess air from refrigerant, ensure that the maximum allowable amount of air in recycled refrigerant is not exceeded, and provide recycled refrigerant that is ready for use.

Mixed/Cross-contaminated Refrigerant

When a vehicle arrives at your shop for A/C service, try to determine if you might be about to work on a contaminated system. Ask the customer questions about work that may have previously been done, and especially, what may have previously been charged into the system. You might find it helpful to use the MACS Customer Questionnaire, which can be found in the back of this manual. (You may photocopy it for your use.) Always try to find out as much as you possibly can about any vehicle on which you intend to perform A/C service, and also about any refrigerant that you intend to purchase. To be as safe as possible, you should use a refrigerant identifier on every system you're going to work on, and on every tank of refrigerant that you intend to buy (see the next page for "When the Label Lies!")

Mixed/cross-contaminated refrigerant is harmful for a number of different reasons.

If you mistakenly draw mixed refrigerant into your service equipment, not only could it possibly damage the equipment, but unless detected, you will contaminate every other vehicle that you use the equipment to service. Even a small amount of one refrigerant mixed with another can ruin the entire batch.

Mixed refrigerants can result in elevated system operating pressures, and this includes CFC-12 mixed with HFC-134a. A mixture of these two refrigerants will raise operating pressures to a point higher than either would ever reach by itself in a "normally" operating system, and how high the pressure goes is determined by the mixture ratio between

CAUTION
NOTICE: RETROFITTED TO R-134a
R-134a REFRIGERANT UNDER HIGH PRESSURE
SYSTEM TO BE SERVICED BY QUALIFIED PERSONNEL ONLY. IMPROPER SERVICE METHODS MAY CAUSE PERSONAL INJURY.
RETROFIT PROCEDURE PERFORMED TO SAE J1661
USE ONLY R-134a REFRIGERANT AND SYNTHETIC OIL #
OR EQUIVALENT, OR A / C SYSTEM WILL BE DAMAGED
DATE
RETROFITTER NAME
ADDRESS
CITY / STATE
REFRIGERANT CHARGE / AMOUNT
LUBRICATION / TYPE
AMOUNT
AUXILIARY LABEL LOCATION

Even though a CFC-12 system may be equipped with a retrofit label and conversion fittings, that doesn't in any way provide "proof" of the type of refrigerant that may be in the system, or its purity. The only way to know for sure is to connect a refrigerant identifier to the system and take a reading.

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When the Label Lies!

Many shop owners and technicians may remember the previously prevalent black market in CFC-12. But as CFC-12's use has waned, a new black market has emerged, this time in HFC-134a.

Cases of counterfeit HFC-134a are not exactly new. Several years ago, a Harp refrigerant cylinder and its box were labeled as containing HFC-134a, when in fact, the refrigerant in the cylinder was CFC-12. A close examination of the box reveals the fraud: Harp manufactures its cylinders and boxes in the United Kingdom, yet the emblem on the box indicates it was manufactured in Portugal.

The box says Portugal, but only the most knowledgeable purchaser would know that legitimate Harp products are packaged in the UK. The tank inside this box was filled with CFC-12.

At the time, the price for CFC-12 in Malaysia - where the cylinder was discovered - was much lower than that for HFC-134a. Profit margin appears to have been the main motive for the alleged fraud in this case.

During 2005, HFC-134a was in short supply. Among other causes, that shortage was fueled by increased demand for motor vehicles in developing nations. More new cars are rolling off assembly lines in these countries, and as the demand for HFC-134a increased, stocks dwindled.

A casual buyer would believe the label, but this tank contained R415B, a blend refrigerant not approved for use in vehicles.

As worldwide supplies shrank, some suppliers resorted to creative and not so creative ways to meet the demand for HFC-134a. In the process, they violated U.S. customs, trademark and environmental laws.

More recently, HFC-134a that does not meet the chemical requirements for purity has been sold in world markets. Now industry purity specifications (SAE J2776 and ARI 700-2006) can be identified on packaging and containers of refrigerant which meets the requirements.

As with everything else, the Latin phrase "caveat emptor" (buyer beware) applies. Be on the look out for counterfeit HFC-134a cylinders at a distributor near you, and always examine the packaging carefully.

You can report incidents of suspected fraud to the EPA's toll-free hotline at 1-800-296-1996.

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the two refrigerants. The raising of system operating pressures above normal can result in poor A/C performance and could also cause damage to system components.

Also, on a recovery/recycling machine so equipped, mixed/cross-contaminated refrigerant inside the machine's tank could reach a pressure high enough to fool the machine into activating its automatic air purge feature. This would cause refrigerant to be released the atmosphere.

Mixed refrigerants cannot be separated by recycling machines and are considered hazardous waste. They must be transported to an off-site facility for reclamation or destruction.

Two More Issues Concerning Refrigerant and System Contamination

Just because a vehicle is equipped with a retrofit label and conversion fittings, it would not be wise to assume that the refrigerant in the system is a match to the fittings and the information on the label. There have also been cases of CFC-12 systems being directly charged with HFC-134a, with no labels, fittings, or any other type of indication that this was done. A vehicle could have passed through any number of hands before entering your shop, and there's no telling what could have happened along the way.

Also keep in mind that even approved chemicals, such as dye or lubricant, can become contaminants if they are in a system in excessive amounts. This also applies to approved OEM vehicle/system manufacturers' flushing material that may not be completely removed from a system at the conclusion of a flushing procedure.

Recovery and Disposal of Contaminated Refrigerant

Under federal law, contaminated refrigerant cannot be vented. Recovery/recycling equipment is not designed to recycle or separate contaminated refrigerants. Contaminated or unknown refrigerant must be removed from a system using dedicated recovery-only equipment, and properly disposed of.

There are currently two types of equipment that can be used to recover contaminated refrigerant:

- Recovery-only units offered by some equipment manufacturers that are specifically designed for this purpose;
- You may dedicate a CFC-12 or HFC-134a recovery unit specifically for the purpose of recovering contaminated refrigerant.

Caution: If the refrigerant contains flammable substances, such as propane and butane, a fire or explosion could occur if the refrigerant is exposed to an ignition source within the equipment. Recovery equipment that has been certified for use with CFC-12 or HFC-134a is not approved for use with a flammable refrigerant and may become a safety hazard if used. Make sure you determine if features have been incorporated into your equipment to guard against these hazards.

Also, refrigerant containing flammable substances may be considered hazardous, and you must follow any local, state or federal requirements governing the storage and disposal of ignitable materials (visit www.ecarcenter.org/ecartour.html for more information on specific disposal requirements).

Contaminated refrigerant must be sent off-site to an EPA certified refrigerant reclaimer for either reclamation or destruction. A list of EPA certified refrigerant reclaimers can be found on the EPA's web site at www.epa.gov/ozone/title6/608/reclamation/reclist.html.

Used Refrigerant from Non-mobile Sources

CFC-12 and HFC-134a are also used in residential and commercial refrigeration systems, such as refrigerators, water chillers and central cooling systems. Many different contaminants and acids may be present in refrigerant recovered from these systems. Automotive-type recovery/recycling equipment will not remove these contaminants.

Refrigerant which contains acids and other contaminants, as well as possibly mixed refrigerants, will cause serious problems if it is used in a mobile A/C system.

Refrigerant from non-mobile sources should not be used unless it has been purchased from a reclamation center which can certify that the refrigerant meets ARI 700 specifications.

Purity of New HFC-134a

In 2006, both the SAE and the ARI issued more stringent standards concerning the purity of new HFC-134a, SAE J2776 and ARI 700-2006.

To meet the ARI 700-2006 and SAE J2776 purity requirements, "volatile impurities" shall not exceed 40 parts per million (ppm). These impurities cannot be identified in the field, and the purity information is not normally part of the refrigerant's Material Safety Data Sheet (MSDS). These impurities have been identified to potentially result in A/C system problems and health issues.

Refrigerant meeting SAE J2776 will have a label on the carton and container stating: "Meets SAE J2776 purity standard." Containers will have 1/2-inch Acme fittings that will attach to the automotive service equipment. Refrigerant containers not having this fitting may not meet the SAE J2776 purity requirements.

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Recovering Refrigerant from Disposable Cylinders

Before they are discarded, disposable refrigerant cylinders should be connected to recovery equipment and brought to a vacuum. This will ensure that all refrigerant has been removed. The cylinder should then be marked "Empty." (Note: Some disposal facilities will not accept these cylinders unless some type of visual assurance exists that the cylinder is completely empty (such as a hole drilled in the cylinder.)

Make sure new HFC-134a you intend to purchase meets the SAE J2776 and/or the ARI 700-2006 purity standard(s), and has a 1/2-inch Acme tank fitting.

Notes: _____

Before they are discarded, disposable refrigerant cylinders should be connected to recovery equipment and brought to a vacuum. This will ensure that all refrigerant has been removed.

Empty refrigerant cylinders should be marked "Empty" before disposal.

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Field Coupling of Flexible Hose Assemblies

SAE J2064 is an engineering standard for joint integrity of hose couplings. This standard is important because it covers the HFC-134a refrigerant hoses you install or repair. Improperly coupled hose assemblies are a reliability problem and result in loss of refrigerant. With smaller refrigerant charges, all the seals, joints and fittings have to be designed to leak far less.

When CFC-12 systems had larger charges, leakage of a pound in a year was considered tolerable. What was once "normal seepage," isn't normal anymore, and motorists now object to both the need for frequent service and the environmental risks.

In the early-to-mid 1990s, high leakage rates were not surprising, but not anymore. In today's small capacity systems, just a few ounces lost is enough to affect performance. And now, the systems are getting even tighter.

A MACS survey showed that half of the replacement coupled hose assemblies are field coupled instead of installing new replacement assemblies. And because some of those shops make up hose assemblies for other shops, they have a multiplier effect.

The following are some suggestions that will probably help you do a better job.

Incorrect tube and hose combination causing tube to seriously deform.

Assembly crimped, rotated and recrimped.

Practical Matters

Typical problems with the field-coupled hoses are damage to the coupling and incorrect crimping.

To assure the best field coupled hose and minimize refrigerant leakage, follow the hose coupling procedures for tube and hose fit and coupling requirements as outlined by the supplier.

Make sure to maintain your crimper and always use the proper dies for the particular job. Beyond that, however, we have to admit that the "by the book" procedure is one that is not always easy to follow. It includes making sure that the fittings and hoses are a within-tolerance fit, and that the crimp meets the dimensions specified.

Do you just cut off the needed length of bulk hose, inserting the needed fittings and turning the crimper's forcing screw until the joint seemed "tight enough?" If so, what you're doing might not be producing a coupling that will not leak.

A major issue is the hose, which has greater size tolerances than the metal fittings. There are cases where the wrong-size fitting was inserted - so loose that if you inverted the hose, the fitting might drop off. We also know of shops that believe "one crimper fits all" and use a hydraulic crimper on an A/C hose. It may produce a tight crimp, but it's been known to crack the hose's barrier lining.

The conscientious shop can do a great job when it comes to the field-assembly and repair of A/C system hoses.

Measure Twice, Crimp Once

Is your bulk A/C hose a quality brand and do you have a hose cutter that produces a neat end? Start by measuring the hose itself. Crimper and fitting manufacturers may provide specs for wall thickness for different size hoses, and there are some hose brands with tolerances that could go outside the listed range. Make sure you know what you have.

Measuring hose wall thickness may seem unnecessary, but if you look closely at the hose and the fitting, you'll see why it's important. Unless the hose wall thickness is within specs, the fitting's ferrule might not crimp the fitting's neck properly.

If it meets the specs, you can use the hose. Be sure to measure the outside diameter at both ends of the needed length of bulk hose before you cut. Some tolerances may be allowed in the hose wall thickness, ranging from plus/minus 0.018-0.028-inch, depending on the type of hose and its diameter. Good hose should be within tolerance, not close to the limits. Don't try to make do with out-of-tolerance hose or by over-crimping the wrong-size fitting.

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Note that the use of hose wall thickness vs. outside diameter is part of one manufacturer's system. Another manufacturer might choose outside and inside diameters for the specifications that help produce field-assembled hoses that meet J2064.

Lube the hose end with refrigeration oil and insert the fitting. Although it won't be a difficult force fit, it shouldn't be drop-off loose either, even with the lubrication. The hose end should be visible in the small inspection hole on the side or end of the ferrule. If it isn't visible, it isn't fully inserted, and you could get a poor crimp.

Appearance Counts

Inspect the crimp for a good visual appearance. It should be uniform and the fitting itself should not be deformed. Oblong, out-of-round or irregular crimps usually indicate worn die carriers or a mismatch of the two dies.

If the correct hose is used with the correct fittings, and the assembly operation is performed properly, you should be able to build and repair hose assembles that meet the requirements for reduced leakage.

Replacement Refrigerants and Retrofitting Mobile A/C Systems

Retrofitting CFC-12 systems to use an alternate refrigerant is permitted, provided that correct procedures are followed.

EPA regulations require that CFC-12 systems undergoing retrofit must have ALL of the CFC-12 recovered, appropriate conversion fittings must be installed on all of the original CFC-12 service ports, a new A/C system information label must be affixed to the vehicle, and a high-pressure compressor cut-off switch must be installed IF the system does not already have one AND it contains a high-pressure refrigerant relief device. In addition, depending on the refrigerant being used, the installation of barrier hoses on systems that do not already have them may be required.

The SAE, at the request of the EPA and the mobile A/C industry, developed retrofit guidelines. Conversion of a CFC-12 system to use HFC-134a is covered by SAE standards J1660, "Fittings and Labels for Retrofit of CFC-12 Mobile Air Conditioning Systems to HFC-134a," and SAE J1661 "Procedure for Retrofitting CFC-12 Mobile Air Conditioning Systems to HFC-134a." Air conditioning system manufacturers' procedures follow these SAE guidelines. Conversion of a CFC-12 system not following these procedures could result in operational problems.

Only CFC-12 and HFC-134a recovery, recycling and charging equipment are currently covered by SAE standards. When and if OEM-approved alternate refrigerants enter the market, SAE standards related to those refrigerants will be issued.

CFC-12 and HFC-134a are the only refrigerants approved by vehicle and A/C system manufacturers. Use of alternate refrigerants which are not approved could result in damage to A/C system components. Servicing mobile A/C systems with alternate refrigerants could also contribute to the contamination of CFC-12 and HFC-134a recycled refrigerant supplies. All mobile A/C system manufacturers encourage the continued use of CFC-12 in systems originally designed to use it. If and when CFC-12 is no longer available, most CFC-12 systems can be retrofitted to operate with an alternate refrigerant.

As determined by the vehicle or system manufacturer, additional retrofit requirements and recommendations may include the installation of new o-rings and/or seals, new desiccant, a different lubricant, replacement of refrigerant controls, increased condenser capacity and other modifications. Not following OEM recommendation may result in system damage, loss of performance and could also affect component warranties.

What About Retrofitting HFC-134a Systems?

HFC-134a systems are designed and tested only for use with HFC-134a and PAG lubricant. There is no published information or industry-recognized tests to establish system cooling performance, system reliability, material compatibility or the potential for chemical damage to the system's lubricant, seals and hoses should a substitute refrigerant be installed in an HFC-134a system.

The U.S. EPA's Significant New Alternative Policy (SNAP)

Under the Significant New Alternative Policy (SNAP), in addition to HFC-134a, the EPA has accepted some other alternate refrigerants that may be used to retrofit CFC-12 systems. However, there are no direct "drop in" replacements for CFC-12 (including HFC-134a), and SNAP does not evaluate refrigerants for system performance or durability. The only refrigerant on the SNAP list that is approved by vehicle and system OEM is HFC-134a.

Table 5 lists refrigerants evaluated by the SNAP.

Tables 6 and 7 list the refrigerant container fittings, service fittings and refrigerant labels for the SNAP-evaluated CFC-12 replacement refrigerants.

Currently, the refrigerants listed under the SNAP are only intended to be used as replacements for CFC-12 in systems originally designed to use CFC-12. The SNAP does not intend that these refrigerants can or should be used as

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TABLE 5 - Motor Vehicle Air Conditioning Substitutes for CFC-12 (Reviewed Under EPA's SNAP Program as of March 29, 2006)

*Acceptable Subject to Use Conditions**

Name (1)	Date	Manufacturer	Components						
			HCFC-22	HCFC-124	HCFC-142b	HFC-134a	Butane (R-600) (3)	Isobutane (R-600a) (3)	HFC 227ea
HFC-134a	3/18/94	Several	-	-	-	100	-	-	-
FRIGC FR-12	6/13/95	Intercool Distribution 800-555-1442	-	39	-	59	2	-	-
Free Zone/ RB-276 (4)	5/22/96	Hi Tech Refrigerants, LLC 800-530-4805	-	-	19	79	-	-	-
Ikon-12	5/22/96	Ikon Corp. 601-868-0755		Composition claimed as confidential business information					
R-406A/ GHG(5)	10/16/96	People's Welding 800-382-9006	55	-	41	-	-	4	-
GHG-HP (5)	10/16/96	People's Welding 800-382-9006	65	-	31	-	-	4	-
GHG-HP Autofrost Chill-It (5)	10/16/96	People's Welding 800-382-9006 McMullen Oil Products 800-669-5730	51	28.5	16.5	-	-	4	-
Hot Shot/ Kar Kool (5)	10/16/96	ICOR 800-357-4062	50	39	9.5	-	-	1.5	-
Freeze 12	10/16/96	Technical Chemical 800-527-0885	-	-	20	80	-	-	-
GHG-X5	6/3/97	People's Welding 800-382-9006	41	-	15	-	-	4	40
SP34E	12/18/00	Solpower 888-289-8866		Composition claimed as confidential business information					
RS-24	12/20/02	Refrigerant Products Ltd		Composition claimed as confidential business information					
R420-A	3/29/06	RMS of Georgia	-	-	12	88	-	-	-

Unacceptable Substitutes

Name (1)	Date	Manufacturer	Reason
OZ-12®	3/18/94	OZ Technology	Flammable blend of hydrocarbons. insufficient data to demonstrate safety
R-176	3/18/94	Arctic Chill	Contain CFC-12, which is inappropriate in a CFC-12 substitute
HC-12a©	6/13/95	OZ Technology	Flammable blend of hydrocarbons. insufficient data to demonstrate safety
Duracool 12a	6/13/95	Duracool Limited	This blend is identical to HC12a© in composition but is manufactured by a different company
R405A	6/13/95	Greencool	Contains a perfluorocarbon, which has extremely high global warming potential and lifetime

**USE CONDITIONS:*

1. *Many refrigerants, including R401A (made by DuPont), R401B (DuPont), R409A (Elf Atochem), Care 30 (Calor Gas), Adak-29/Adak-12 (TACIP Int'l), MT-31 (Millennia Tech), and ES-12R (Intervest), have not been submitted for review in motor vehicle air conditioning, and it is therefore illegal to use these refrigerants in such systems as an alternative to CFC-12.*
2. *Acceptable Subject to Use Conditions regarding fittings, labeling, no drop-in, and compressor shutoff switches. Unacceptable; illegal for use as a CFC-12 substitute in motor vehicle air conditioners*
3. *Although some blends contain flammable components, all blends that are Acceptable Subject to Use Conditions are nonflammable as blended.*
4. *Freezone contains 2% of a lubricant*
5. *HCFC-22 content results in an additional use condition: must be used with barrier hoses*

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Table 6 - MVAC Refrigerants Fitting Sizes

These fittings and labels must be used with alternative refrigerants when used in motor vehicle air conditioning systems. For more details, see EPA's fact sheet titled "Choosing and Using Alternative Refrigerants for Motor Vehicle Air Conditioning," available from the hotline and on the website.

The list includes all refrigerants found acceptable subject to use conditions in motor vehicle air conditioning as of December 18, 2000.

REFRIGERANT	CONTACT	HIGH SIDE SERVICE PORT			LOW SIDE SERVICE PORT			30-LB. CYLINDERS			SMALL CANS		
		Diameter (inches)	Pitch (threads/inch)	Thread Direction	Diameter (inches)	Pitch (threads/inch)	Thread Direction	Diameter (inches)	Pitch (threads/inch)	Thread Direction	Diameter (inches)	Pitch (threads/inch)	Thread Direction
CFC-12 post-1987	multiple	6/16	24	Right	7/16	20	Right	7/16	20	Right	7/16	20	Right
CFC-12 (pre-1987)		7/16	20	Right	7/16	20	Right	7/16	20	Right	7/16	20	Right
HFC-134a	multiple	quick-connect			quick-connect			8/16	16 Acme	Right	8/16	16 Acme	Right
Freeze 12	Technical Chemical 800-527-0885	7/16	14	Left	8/16	18	Right	6.16	18	Right	6/16	24	Right
Free Zone/ RB-276	Refrigerant Gases 888-373-3066	8/16	13	Right	9/16	18	Right	9/16	18	Right	6/16	24	Left
Hot Shot	ICOR 800-357-4062	10/16	18	Left	10/16	18	Right	10/16	18	Right	5/16	24	Right
McCool Chill-It	McMullen Oil Products, Inc. 800-669-5730	6/16	24	Left	7/16	20	Left	.368	26	Right	14mm	1.25mm spacing	Left
GHG-X4 Autofrost	People's Welding 800-382-9006	.305	32	Right	.368	26	Right	.368	26	Right	14mm	1.25mm spacing	Left
GHG-X5		8/16	20	Left	9/16	18	Left	9/16	18	Left	not sold in small cans		
R-406A		.305	32	Left	.368	26	Left	.368	26	Left	8/16	20	Left
GHG-P		not yet developed*											
Ikon-12/ Ikon A	Ikon 555-345-2707	not yet developed*											
FRIGC FR-12	Intercool 800-555-1442	quick-connect, different from HFC-134a			quick-connect, different from HFC-134a			8/16	20	Left	7/16	20	Left
SP34E	Solpower 888-289-8866	7/16	14	Right	8/16	18	Left	8/16	18	Left	5/16	24	Left
RS-24	Refrigerant Solutions Ltd	quick-connect, different from HFC-134a and FRIGC FR-12			quick-connect, different from HFC-134a and FRIGC FR-12			quick-connect, different from HFC-134a and FRIGC FR-12			quick-connect, different from HFC-134a and FRIGC FR-12		
R420	RMS of Georgia	0.5625 (9/16)	18	Right	0.5625 (9/16)	18	Left	0.5625 (9/16)	18	Left	0.5625 (9/16)	18	Right

* These refrigerants have not been marketed yet; therefore, fittings have not been developed.

Table 7 - MVAC Refrigerant Label Colors

REFRIGERANT	BACKGROUND
CFC-12	White
HFC-134a	Sky Blue
Freeze 12	Yellow
Free Zone / RB-276	Light Green
Hot Shot	Medium Blue
GHG-X4	Red
R-406A	Black
GHG-X5	Orange
GHG-HP	not developed yet*
Ikon-12 / Ikon A	not developed yet*
FRIGC FR-12	Grey
SP34E	Tan
RS-24	Gold
R420A	Dark Green (PMS #347)

To comply with the conditions on the use of motor vehicle refrigerants, a detailed label must be applied that features a unique background color. This table summarizes the colors chosen for the refrigerants listed as of June 3, 1997. The information required for each label is listed in EPA's fact sheet titled "Choosing and Using Alternative Refrigerants for Motor Vehicle Air Conditioning," available from EPA's world wide web site and from the Stratospheric Ozone Hotline at 800-296-1996.

* These refrigerants have not been marketed yet; therefore, label colors have not been developed.

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replacements for HFC-134a. However, in the future, the EPA may identify replacement refrigerants for HFC-134a, and vehicle and A/C system manufacturers will decide if these refrigerants meet their approval.

Current mobile A/C systems are not designed to use blend refrigerants.

Blends refrigerants may provide cooling performance when initially charged. However, each refrigerant in a blend has a different pressure/temperature relationship, and different leakage rates through the A/C system hoses. Blends can separate while in use, and a leak in a system can allow one component of the blend to escape at a faster rate. This partial leakage can change the entire refrigerant mixture and cause system operating problems.

A Word on Flammable Refrigerants

Replacement refrigerants which are or can become flammable have been sold for use in mobile A/C systems. Current mobile A/C systems are not designed to use flammable refrigerants, and using a flammable refrigerant as a replacement for CFC-12 is prohibited by federal law. The use of flammable refrigerant to replace any mobile A/C system refrigerant is also currently illegal in the following states: Arizona, Arkansas, Connecticut, Florida, Idaho, Indiana, Iowa, Kansas, Louisiana, Maryland, Montana, Nebraska, North Dakota, Oklahoma, Texas, Utah, Virginia, Washington and Wisconsin, as well as in the District of Columbia.

Caution should be taken before working on any system suspected of containing flammable refrigerant; some electronic leak detectors could become an ignition source if being used to find leaks in a system containing flammable refrigerant; components inside many recovery/recycling machines can also serve as a possible ignition source if the equipment is being used to recover flammable refrigerant. Either of these situations could result in a fire or explosion.

Connection and disconnection of service equipment often results in the release of a small amount of refrigerant at the service ports. If the refrigerant released in these circumstances is flammable, and there is a source of ignition nearby (such as a torch or pilot light on a gas appliance), a fire or explosion could occur.

Flammable refrigerants are sometimes mixed with CFC-12, HFC-134a or HCFC refrigerants in an A/C system. This is another reason why the use of a refrigerant identifier should be incorporated into all mobile A/C refrigeration system service procedures. The identifier will indicate the presence of the flammable refrigerant.

WARNING: REMOVAL AND HANDLING OF FLAMMABLE REFRIGERANTS MAY BE DANGEROUS.

Fuel System Fittings

CAUTION: FUEL INJECTION SYSTEMS ON MANY VEHICLES CONTAIN A SERVICE PORT THE SAME SIZE AS ONE OF THE CFC-12 A/C SYSTEM SERVICE PORTS. BE CAREFUL NOT TO ATTACH A/C SERVICE EQUIPMENT TO A VEHICLE'S FUEL SYSTEM!

Notes: _____

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SERVICING OF FUTURE MOBILE AIR CONDITIONING SYSTEMS

As the world becomes more concerned about the global environment, the type and amount of refrigerant use in mobile air conditioning systems has resulted in system design changes, new service procedures and equipment to reduce lifetime emissions.

The global automotive industry and the U.S. EPA are evaluating containment of refrigerants and the possibility of new replacement refrigerants that will affect the service of future systems.

European Phase Out of HFC-134a

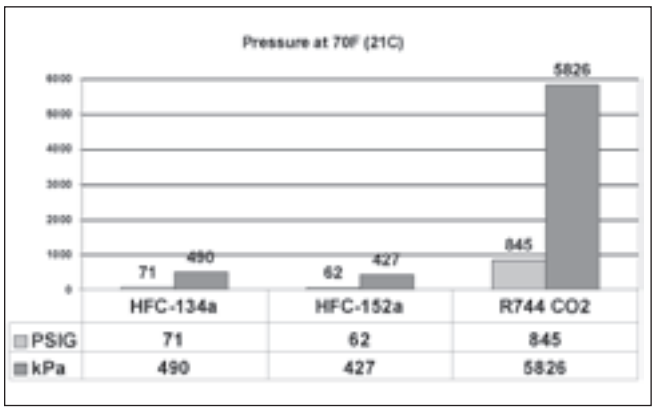
Starting in 2011, the A/C systems in vehicles sold in Europe must use a refrigerant that has a Global Warming Potential (GWP) of less than 150. Automobile manufacturers must meet this requirement for that marketplace, and there is the possibility that vehicles having a refrigerant other than HFC-134a will have to be serviced in the United States.

HFC-134a has been considered as a global refrigerant and with the requirement for its phase-out in Europe, the industry is striving to identify a replacement refrigerant that can be used in a new, environmentally friendly, global mobile air conditioning system. Several possible approaches, including unique air conditioning system designs and new refrigerants are being considered.

R744 (Carbon Dioxide) Systems

To meet the European low GWP refrigerant requirements, vehicle manufacturers have developed mobile air conditioning systems that use carbon dioxide (R744) as a refrigerant. R744 has the lowest GWP value of new refrigerants being considered. Carbon dioxide systems will require different types of components compared to HFC-134a systems.

R744 systems operate at pressures 5 to 10 times higher than to HFC-134a and HFC-152a systems. The chart below compares the container pressure for HFC-134a, R744 and HFC-152a at 70° F (21° C). These pressures will go higher as the containers become warmer.



Carbon dioxide is hazardous, and therefore, also requires system design features to address safety for vehicle occupants and service personnel. In addition, new service equipment and service procedures, as well as specific training, and possible certification, will be required for technicians servicing R744 systems.

HFC-152a Systems

HFC-152a is another refrigerant that can meet the European Community's requirements. HFC-152a has a lower GWP value than HFC-134a, but a higher GWP value than R744. HFC-152a has similar operating pressures to HFC-134a. However, HFC-152a is flammable, so its use would also require system design features to address vehicle occupant and service personnel safety.

Two types of HFC-152a systems have so far been demonstrated; the direct expansion type and the secondary loop type.

The direct expansion type is just like an HFC-134a system, except that to address the flammability issue, system safety features are required. The secondary loop type incorporates a direct expansion refrigerant circuit located in the engine compartment with a chiller that cools a non-flammable liquid. The non-flammable liquid is circulated to a cooling coil that replaces the evaporator. This provides isolation between the flammable refrigerant and the passenger compartment.

As with R744, new service equipment, procedures, training and possible certification, will be required for technicians servicing HFC-152a systems.

Other Alternative Refrigerants

New chemicals being developed as replacement refrigerants with low GWP ratings may also enter the marketplace. The future mobile A/C systems in which they are intended for use will be specifically designed to use these new refrigerants.

SAE I-MAC Program

In 2004, the industry established the industry and government sponsored SAE Improved Mobile Air Conditioning (I-MAC) Cooperative Research Program to reduce system energy requirements, as well as reduce refrigerant emissions from HFC-134a mobile air conditioning systems.

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The goals of the project were to identify technologies that will:

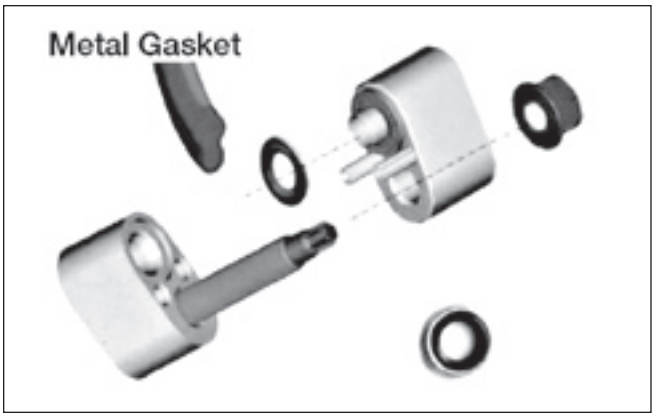
* Reduce direct system refrigerant leakage by 50%.
* Improve system efficiency by 30%.
* Reduce system loads by 30%.
* Reduce the impact of service refrigerant losses by 50%.

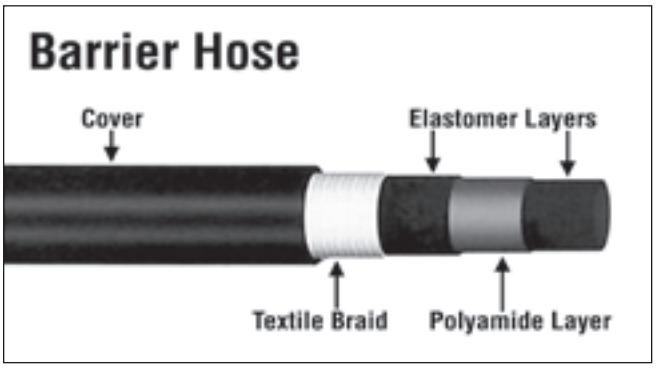
The service sector contributes to the release of refrigerant. Using professional service procedures and equipment will reduce the release of HFC-134a. The I-MAC goal is reducing refrigerant loss by 50% through the use of better equipment and improved procedures.

Improved HFC-134a Systems

Improved HFC-134a systems are more efficient, use less refrigerant charge and have less refrigerant loss over their lifetime.

The SAE I-MAC Cooperative Research program accomplished its goals and many of these technologies have been introduced into HFC-134a mobile air conditioning systems and service equipment. As new technologies are developed, expect to see further changes in mobile A/C systems.





Reduced Refrigerant Loss Systems: The use of high quality flexible hose material and improved pipe connections reduce system refrigerant loss.

Notes: _____

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Appendix - SAE Standards Applicable to Mobile A/C System Service

Since the first SAE document J513 in January 1936, which conforms to ANSI B70-1974, SAE refrigeration flare fittings have been an industry standard. In April 1953, SAE J639 provided standards for system service access fittings currently used by the automotive and commercial industry.

To prevent mis-connections, SAE J639 was revised in the 70s to provide different size system service connections on CFC-12 mobile A/C systems. The use of different high and low refrigeration service access fittings are not used by the commercial industry.

When the mobile industry changed refrigerants from CFC-12 to HFC-134a new unique quick couple service fittings were developed to reduce venting and possible mixing of refrigerants during service of mobile A/C systems. New unique quick couple service fittings have been developed for R744 (carbon dioxide) and HFC-152a mobile A/C systems and are identified in J639.

The mobile air conditioning industry established replacement refrigerant criteria, resulting in new SAE documents.

The industry/EPA field study of mobile A/C systems identified what level of contamination could be expected from used CFC-12 refrigerant and established equipment requirements and the purity levels for on-site recycled refrigerant. Based on that early study, SAE and industry have identified that only uncontaminated CFC-12 and HFC-134a refrigerant, removed from a mobile A/C system and recycled on-site, using equipment meeting SAE Standards, is acceptable for reuse. All other used or contaminated refrigerant from other sources must be sent off-site for processing and must meet the specific ARI recycled purity specification.

Summary of Standards

At the request of the U.S. Environmental Protection Agency, SAE Interior Climate Control Standards Committee established working groups to address the needs of the auto industry regarding environmental concerns. This summary includes SAE documents that have been developed for system design requirements, refrigerant emissions, contamination and handling of refrigerants used in the mobile air conditioning industry.

With the requirements to phase-out HFC-134a mobile air conditioning systems in Europe, starting in 2011, replacement refrigerants will be entering the global marketplace. The SAE Interior Climate Control Standards Committee is developing new international standards and practices addressing the use of new alternate refrigerants, for system design, service equipment and technician procedures.

Industry Criteria and Guidelines

SAE J2219: "Mobile Air Conditioning Industry and Guidelines"

This document was originally published in 1991 and revised in 1994. The purpose of this SAE Information Report is to provide information on refrigerant issues of concern to the mobile air conditioning industry.

System Design Guidelines

SAE J639: "Safety Standards for Motor Vehicle Refrigerant Vapor Compression Systems"

This SAE Standard Practice is restricted to refrigerant vapor compression systems that provide cooling and/or heating for the passenger compartment. This document provides design standards for refrigerant containment and safety for these systems. Also included are cautionary statements for the mobile air conditioning service industry to alert service technicians to the inadvisability and the possible health and safety effects associated with venting refrigerant during service. It is not intended to restrict the use, or further development, of other types of refrigeration systems for passenger compartment cooling. Should other systems be found practical, this document may be amended or an additional standard safety practice created for such systems. This document addresses only CFC-12 (R12), HFC-134a (R134a), HFC-152a (R152a) a flammable gas and carbon dioxide (R744) refrigerants. To prevent system contamination, and address safety issues, all refrigerants used in mobile air conditioning vapor compression systems require unique service fittings. The unique service fittings minimize the potential for system refrigerant contamination during service activity.

SAE J2727: "R134a Mobile Air Conditioning System Leakage Chart"

Current industry standards do not exist for determining refrigerant emissions from mobile air conditioning systems. Test procedures are not common between production component suppliers in establishing leakage values. This "System Leakage Chart" has been developed from industry experience of expected refrigerant leakage gains from system design resulting from technology changes. It provides a rating value of various technologies that are currently available. The "Leakage Chart" can be expanded as new technologies are offered and/or developed. This document provides the information to develop an Excel file template "Leakage Chart" for making system analysis. It is not the intent of this practice to define the refrigerant emissions from a mobile air conditioning system. It is to only define a system rating based upon the technology used. Future development of SAE Standards for determining mobile air conditioning refrigerant emissions such as system static and dynamic min-shed test procedures will provide a procedure for determining system emissions. Publish in 2005; revised July 2007.

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System Components

SAE J51: "Automotive Air Conditioning Hose"

This document covers CFC-12 emission rates for refrigerant hose use on mobile air conditioning systems. This document does not cover the hose coupling integrity.

SAE J2064: "R134a Refrigerant Automotive Air Conditioning Hose"

The revised document addresses hose assembly refrigerant leakage and was published in 2005. This SAE Standard covers hose and hose assemblies intended for conducting liquid and gaseous R134a refrigerant in automotive air-conditioning systems. The hose shall be designed to minimize permeation of R134a refrigerant, contamination of the system, and to be functional over a temperature range of -30° C to 125° C. Specific construction details are to be agreed upon between user and supplier. A hose marked "J2064" signifies that it has been coupled, tested, and has met the requirements of SAE J2064. It is the hose assembly manufacturer's responsibility to see that the assemblies meet the specified acceptance criteria for this specification.

Service Activities

SAE J2196: "Service Hose for Automotive Air Conditioning"

This defines service equipment (gauge lines) hose emission rates and construction requirements for service hoses. Revised November 1998.

SAE J2197: "HFC-134a Service Hose Fittings for Automotive Air Conditioning Service Equipment"

To prevent mixing of HFC-134a with other refrigerants, a 1/2 inch Acme thread fitting for containers was developed by the "Compressed Gas Association" (CGA). This 1/2 inch Acme thread is also required on HFC-134a automotive service equipment. Revised March 1997.

SAE J2297: "Stability and Compatibility Criteria of Fluorescent Refrigerant Leak Detection Dyes for Mobile R134a Air Conditioning Systems"

This provides requirements for material compatibility of trace dye material with mobile A/C systems. Published September 1996.

SAE J2298: "Use of Refrigerant Leak Detection Dyes for Service of Mobile Air Conditioning Systems"

This covers the procedures, including safety requirements, when using trace dye to determine if the A/C system has a refrigerant leak. Published September 1996.

SAE J2299: "Performance Requirements for Leak Detection Dye Injection Equipment"

This document establishes the requirements for the equipment required to install trace dye material into the refrigerant circuit of a mobile A/C system. Published September 1996.

SAE J2670: "Stability and Compatibility Criteria for Additives and Flushing Materials Intended for Use in Vehicle Air-Conditioning Systems Using R134a"

The purpose of this standard is to provide testing and acceptance criteria to evaluate the stability and compatibility of chemicals, including flushing materials and additives (e.g., to enhance lubrication, durability, cooling performance, energy performance, prevent/fix leaks) intended for use in R134a vehicle air conditioning systems. Successful completion of all requirements contained in this specification indicates acceptable compatibility with the A/C system materials, but does not suggest that the additive improves system performance in any way. This SAE standard applies to any and all additives and chemical solutions intended for aftermarket use in the refrigerant circuit of vehicle air-conditioning systems. This standard provides testing and acceptance criteria for determining the stability and compatibility of additives and flushing materials (solutions) with A/C system materials and components, that may be intended for use in servicing or operation of vehicle air conditioning systems. This standard does not provide test criteria for additive, compressor lubricant, or flushing solution effectiveness; such testing is the responsibility of the additive and/or solution manufacturer/supplier. It is not the intent of this document to identify the requirements for Standard J2297 Ultraviolet Leak Detection: Stability and Compatibility Criteria of Fluorescent Refrigerant Leak Detection Dyes for Mobile R134a Air-conditioning Systems. All leak detection materials must meet the requirements of J2297. Published in 2005.

SAE J2776: "Refrigerant Purity and Container Requirements for New HFC-134a 1,1,1,2-Tetrafluoroethane Refrigerant Used in Mobile Air-Conditioning Systems"

The purpose of this SAE Standard is to establish the minimum level of purity required and container specifications for new HFC-134a refrigerant used in mobile air-conditioning (A/C) systems. The refrigerant shall meet all the requirements as identified in ARI 700-2004 and all future ARI standards for HFC-134a. Published October 2006.

Technician Service Procedures

SAE J1628: "Technician Procedure for Using Electronic Refrigerant Leak Detectors for Service of Mobile Air Conditioning Systems"

This document provides guidelines for the technician when using an electronic leak detector in determining a system refrigerant leak. Published November 1998.

SAE J1989: "Recommended Service Procedure for the Containment of CFC-12 (R12)"

This document covers the technician refrigerant recovery/recycling procedures when servicing CFC-12 (R12) mobile A/C systems and identification of excess NCG's. Revised November 1998.

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SAE J2211: "Recommended Service Procedure for the Containment of HFC-134a (R134a)"

This document covers the technician refrigerant recovery/recycling procedures when servicing HFC-134a mobile A/C systems and identification of excess NCGs. Revised November 1998.

Service Equipment

SAE J1627: "Rating Criteria for Electronic Leak Detectors"

This document establishes the criteria for electronic leak detectors to identify refrigerant leaks. Published August 1995.

SAE J2791: "HFC-134a Refrigerant Electronic Leak Detectors, Minimum Performance Criteria"

The purpose of this SAE Standard is to establish minimum performance criteria for electronic probe-type leak detectors intended for use in automotive air conditioning systems with HFC-134a refrigerant.

Improved design requirements for refrigerant containment of HFC-134a mobile air conditioning systems have resulted in reduced annual system refrigerant emissions. Identification of potential system refrigerant leakage during servicing from these reduced emission systems requires improved detection capability of leak detection devices. These revisions in SAE J2791 establish a new certification procedure and new leak detection value requirements for certification of electronic probe-type leak detectors. Published January 2007.

SAE J1770: "Automotive Refrigerant Recovery/Recycling Equipment intended for Use with both R12 and R134a"

This document establishes the requirements for a single cabinet (enclosure) having recovery/recycle equipment for both R12 and R134a with a common refrigerant circuit. It establishes the specifications that assure that the equipment will not cross contaminate refrigerant under normal operating conditions. Published October 1995.

SAE J1771: "Criteria for Refrigerant Identification Equipment for Use with Mobile Air Conditioning Systems"

This establishes specifications for refrigerant identification equipment used to identify refrigerant purity. This was developed due to the refrigerant contamination problems occurring in mobile A/C systems and refrigerant supplies. Revised November 1998.

Recovery/Recycle Equipment

The mobile air conditioning industry has established SAE performance certification requirements for recovery/recycle equipment and purity requirements for CFC-12 and HFC-134a. Equipment certified under ARI 740 (which does not have a purity standard) cannot be used in the industry since it does not comply with SAE or Section 609 of the Clean Air Act requirements.

SAE J1990: "Recovery and Recycle Equipment for Mobile Automotive Air Conditioning Systems"

This covers equipment certification for recovery/recycling CFC-12 to meet the standard of purity. Revised February 1999.

SAE J1991: "Standard of Purity for use in Mobile Air Conditioning Systems"

This identifies the purity level of recycled R12 refrigerant after a contaminated sample has been processed in SAE J1990. Revised February 1999.

SAE J2099: "Standard of Purity for Recycled HFC-134a (R134a) for use in Mobile Air Conditioning Systems"

This identifies the purity level of recycled R134a refrigerant after a contaminated sample has been processed in SAE J2788. Revised February 1999.

SAE J2209: "CFC-12 (R12) Refrigerant Recovery Equipment for Mobile Automotive Air Conditioning Systems"

This covers equipment certification for recovery of CFC-12 from mobile A/C systems to be processed in SAE J1990 recovery/recycling equipment or be sent off-site for process to meet ARI 700-purity level. Revised February 1999.

SAE J2296: "Retest of Refrigerant Cylinder"

Refrigerant containers used with recovery and recovery/recycle equipment must be inspected every 5 years to assure their safety. This document covers the retesting of these containers. Revised November 1999.

SAE J2788: "HFC-134a (R134a) Recovery/Recycling Equipment and Recovery/Recycling/Recharging for Mobile Air-Conditioning Systems"

The purpose of this SAE Standard is to establish the specific minimum equipment performance requirements for recovery and recycling of HFC-134a that has been directly removed from, and is intended for reuse in, mobile air-conditioning (A/C) systems. It also is intended to establish requirements for equipment used to recharge HFC-134a to an accuracy level that meets Section 9 of this document and SAE J2099. The requirements apply to the following types of service equipment and their specific applications.

This standard supersedes the requirements of SAE J2210 to reduce refrigerant emissions during servicing and provides requirements for charging refrigerant into mobile air conditioning systems. This SAE Standard is to establish the specific minimum equipment requirements for the recovery/recycling of HFC-134a that has been directly removed from, and is intended for reuse in, mobile air-conditioning systems and recovery/recycling and system recharging of recycled or virgin HFC-134a. Establishing such specifications will ensure that system operation with recycled HFC-134a will provide the same level of performance and durability as new refrigerant. Published December 2006.

SAE J2810: "HFC-134a (R134a) Refrigerant Recovery Equipment for Mobile Automotive Air-Conditioning Systems"

The purpose of this SAE Standard is to provide minimum performance and operating feature requirements for the recovery of HFC-134a (R134a) refrigerant to be returned to a refrigerant reclamation facility that will process it to the appropriate ARI 700 Standard or allow for recycling of the recovered refrigerant to SAE J2788 specifications by

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using SAE J2788-certified equipment. It is not acceptable that the refrigerant removed from a mobile air-conditioning (A/C) system with this equipment be directly returned to a mobile A/C system.

This standard supersedes the requirements of SAE J1732. Because of environmental concerns, SAE J2788 recovery/recycle standard established more stringent equipment performance features and requirements for on-site recovery, recycle and recharge of HFC-134a (R134a) in mobile air-conditioning (A/C) systems. This standard is for HFC-134a (R134a) recovery (extraction)-only equipment that is intended to be used in conjunction with the on-site recovery/recycling (R/R) equipment used at service facilities, for off-site refrigerant reclamation or other environmentally legal use, such as destruction of refrigerants or in another compound. Published October 2007.

Replacement Refrigerant Requirements

Four documents were developed at the request of EPA to provide engineering guidelines for alternate refrigerants being considered for mobile A/C systems.

SAE J1657: "Selection Criteria for Retrofit Refrigerants to Replace CFC-12 (R12) in Mobile Air Conditioning Systems"

This includes flammability, ozone depletion, and toxicity of the refrigerant. It also identifies refrigerant and lubricant system and material compatibility requirements to be usable in the mobile A/C system. Published February 1999.

SAE J1658: "Alternate Refrigerant Consistency Criteria for Use in Mobile Air Conditioning Systems"

Blend refrigerants consist of a combination of more than one refrigerant. This document identifies the proper handling procedure, vapor or liquid phase, and identifies when the remaining container contents cannot be used due to improper blend consistency. Published February 1999.

SAE J1659: "Vehicle Testing Requirements for Replacement Refrigerants for CFC-12 (R12) Mobile Air Conditioning Systems"

This identifies vehicle tests that must be conducted to establish system performance changes due to the alternate refrigerant. Published February 1999.

SAE J1660: "Fittings and Labels for Retrofit of CFC-12 (R12) Mobile Air-Conditioning Systems to HFC-134a (R134a)"

This SAE Recommended Practice describes the specific measures required to meet SAE established criteria when retrofitting CFC-12 (R12) mobile air-conditioning (A/C) systems to HFC-134a (R134a), with regards to fittings and labeling. This document is complete only when combined with the requirements of SAE J1657.

SAE J1661: "Procedure Retrofitting CFC-12 (R12) Mobile Air-Conditioning Systems to HFC-134a (R134a)"

The purpose of this SAE Recommended Practice is to provide a service procedure for retrofitting a CFC-12 (R12) system to HFC-134a (R134a) while preserving performance and integrity of the air-conditioning (A/C) system. The steps outlined in this procedure are complete when combined with good service practices and the vehicle manufacturer's recommendations (if available) for retrofitting their models. Separate service equipment, for CFC-12 (R12) and HFC-134a (R134a), including refrigerant recovery/recycle (R/R), service manifolds, vacuum pumps, and charging equipment shall be used to preserve the purity of the refrigerants and the mobile A/C systems. This procedure will minimize release of refrigerant to the atmosphere, and will preserve the integrity of the recycled CFC-12 (R12) and HFC-134a (R134a) supplies. This document applies to A/C systems used to cool the passenger compartment of automobiles, light trucks, and other vehicles with similar CFC-12 (R12) systems. Due to technical advancements in recent years, this procedure is recommended for common vehicle platforms produced in the mid-1980s and later. Vehicles produced before this time period may require additional retrofit requirements. A/C systems used on mobile vehicles for refrigerated cargo that have hermetically sealed systems are not covered by this document. This document is only complete when combined with the requirements of SAE J1657 "Selection Criteria for Retrofit Refrigerants to Replace CFC-12 (R12) in Mobile Air-conditioning Systems."

SAE J1662: "Compatibility of Retrofit Refrigerants with Air-Conditioning Materials"

Seals, hoses and "O" rings used in CFC-12 systems may not be compatible with some alternate refrigerants and could break down causing system failures. This document covers test procedures for establishing material compatibility. Published November 1998.

To obtain further information or to purchase documents from SAE International visit their website at:
www.sae.org/climatecontrolstds
Or contact:
USA Toll Free: 1-877-606-7323 • Outside US and Canada: 1-724-776-4970
E-mail: CustomerService@sae.org

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Notes:

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MVAC RECOVER, RECOVER/RECYCLE OR RECOVER/RECYCLE/RECHARGE EQUIPMENT CERTIFICATION FORM

1 _____
NAME OF ESTABLISHMENT

_____
STREET

_____
CITY, STATE, ZIP CODE

_____
TELEPHONE NUMBER

2 _____
NAME OF EQUIPMENT MANUFACTURER & MODEL NUM

_____
SERIAL NUMBER(S) YEAR

3 I certify that I have approved recover, recover/recycle, or recover/recycle/recharge equipment under Section 609 of the Clean Air Act. I certify that only properly trained and certified technicians operate the equipment and that the information given above is true and correct.

_____
SIGNATURE OF OWNER/OPERATOR DATE

_____
NAME (PRINT) TITLE

SEND THIS FORM TO THE EPA REGIONAL OFFICE LISTED UNDER YOUR STATE OR TERRITORY IN WHICH THE ESTABLISHMENT IS LOCATED.

MAILING ADDRESSES CAN BE FOUND ON THE REVERSE SIDE OF THIS FORM.

MVAC RECOVER, RECOVER/RECYCLE OR RECOVER/RECYCLE/RECHARGE EQUIPMENT CERTIFICATION FORM INSTRUCTIONS

Motor vehicle refrigerant recover, recover/recycle, or recover/recycle/recharge equipment must be acquired by January 1, 1992 and certified to EPA on or before January 1, 1993 under Section 609 of the Clean Air Act. To certify your equipment, please complete the above form according to the following instructions and mail to the appropriate EPA region based on where your establishment is located.

1 Please provide the name, address, and telephone number of the establishment where the equipment is located.

2 Please provide the name brand, model number, year and serial number(s) of the equipment acquired for use at the above establishment.

3 The certification statement must be signed by the person who has acquired the equipment (the person may be the owner of the establishment or another responsible officer). The person who signs is certifying that they have acquired the equipment, that each individual authorized to use the equipment is properly trained and certified, and that the information provided is true and correct.

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EPA REGIONAL OFFICES

Send your form to the EPA office listed under the state or territory in which the establishment is located.

Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, Vermont
CAA section 609 Enforcement Contact; EPA Region I; Mail Code SEA; JFK Federal Building; One Congress Street, Suite 1100; Boston, MA 02114-2023

New York, New Jersey, Puerto Rico, Virgin Islands
CAA section 609 Enforcement Contact; EPA Region II (2DECA-AC); 290 Broadway, 21st Floor; New York, NY 10007-1866

Delaware, District of Columbia, Maryland, Pennsylvania, Virginia, West Virginia
CAA section 609 Enforcement Contact; EPA Region III--Wheeling Operations Office; Mail Code 3AP12; 303 Methodist Building; 11th and Chapline Streets; Wheeling, WV 26003

Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, South Carolina, Tennessee
CAA section 609 Enforcement Contact; EPA Region IV(APT-AE); Atlanta Federal Center; 61 Forsyth Street, SW.; Atlanta, GA 30303

Illinois, Indiana, Michigan, Minnesota, Ohio, Wisconsin
CAA section 609 Enforcement Contact, EPA Region V (AE17J); 77 West Jackson Blvd.; Chicago, IL 60604-3507

Arkansas, Louisiana, New Mexico, Oklahoma, Texas
CAA section 609 Enforcement Contact; EPA Region VI (6EN-AA); 1445 Ross Avenue, Suite 1200; Dallas, Texas 75202

Iowa, Kansas, Missouri, Nebraska
CAA section 609 Enforcement Contact; EPA Region VII; Mail Code APCO/ ARTD; 901 North 5th Street; Kansas City, KS; 66101

Colorado, Montana, North Dakota, South Dakota, Utah, Wyoming
CAA section 609 Enforcement Contact, EPA Region VIII, Mail Code 8ENF-T, 999 18th Street, Suite 500, Denver, CO 80202-2466

American Samoa, Arizona, California, Guam, Hawaii, Nevada
CAA section 609 Enforcement Contact; EPA Region IX; Mail Code AIR-5; 75 Hawthorne Street; San Francisco, CA 94105

Alaska, Idaho, Oregon, Washington
CAA section 609 Enforcement Contact; EPA Region X (OAQ-107); 1200 Sixth Avenue; Seattle, WA 98101

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AIR CONDITIONING & HEATING CUSTOMER QUESTIONNAIRE

CUSTOMER
Name_____ **Phone**_____ **Date**_____

Address_____ **City**_____ **State**_____ **Zip**_____

VEHICLE
Year_____ **Make**_____ **Model**_____ **Color**_____

A/C System Type – ❒ Manual ❒ Auto. Temp. Control ❒ Dual / Rear Auxiliary Unit

PROBLEM / SYMPTOM

❑ No A/C	❑ No Heat	❑ No Defrost	❑ Poor Cooling	❑ Poor Heating
❑ Improper Fan/Blower Operation	❑ Air From Wrong Outlet(s)	❑ No Temperature Control	❑ Noise Inside Car	❑ Noise Under Hood
❑ Interior Water Leak	❑ Engine Coolant Leak	❑ Warning Light(s) On	❑ Odor	❑ Other* (See Below)

WHEN DOES THE PROBLEM OCCUR?

❑ Always	❑ Intermittent	❑ When Hot	❑ When Cold	❑ At Start Up
❑ During Warm Up	❑ At Idle	❑ High Engine Speeds	❑ Driving Away From Stop	❑ At Road Speeds

Have there been any previous attempts to repair this problem? ❒ No ❒ Yes
If there were previous repair attempts, what was done? (What parts were installed, etc.)

_____

_____

Did previous repairs help the problem? ❒ No ❒ Some ❒ A lot ❒ At first, but not now.
Have repairs or service of any kind been recently performed to the vehicle? ❒ No ❒ Yes
If so, exactly what was done?

_____

_____

***FURTHER DESCRIPTION OF THE PROBLEM**

_____

_____

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A/C / HEATING / VENTILATION / COOLING SYSTEM CHECKLIST

VEHICLE
Year_____ **Make**_____ **Model**_____ **Engine**_____

V.I.N._____ **System Type – ❒ R134a ❒ R12 ❒ Retrofitted ❒ Front ❒ Rear**

CUSTOMER
Name_____ **Phone**_____ **Date**_____

Address_____ **City**_____ **State**_____ **Zip**_____

Refrigerant I.D./Analysis - R134a_____**% R12**_____**% Air**_____**% Other**_____**%**

Gauge Readings – High Side_____**psi Low Side**_____**psi @**_____**RPM**

COMPONENT	OK	REPAIR	COMPONENT	OK	REPAIR
1. Belts			**14. Electric Cooling Fan(s)**		
Condition	❒	❒	Mounting	❒	❒
Tension	❒	❒	Operation	❒	❒
2. Belt Tensioner	❒	❒	Noise	❒	❒
3. Pulleys/Idler Pulley			Electrical Connections	❒	❒
Alignment/Spacing	❒	❒	**15. Fan Clutch**		
4. Compressor			Operation	❒	❒
Leakage	❒	❒	Fluid Leakage	❒	❒
Mounting/Alignment	❒	❒	**16. Radiator**		
Noise	❒	❒	Leakage	❒	❒
5. Compressor Clutch			Mounting	❒	❒
Air Gap	❒	❒	Cleanliness	❒	❒
Bearing	❒	❒	Hoses and Clamps	❒	❒
Field Coil	❒	❒	**17. Coolant Reservoir**	❒	❒
Electrical Connections	❒	❒	**18. Pressure Cap**	❒	❒
Surge Suppression Diode	❒	❒	**19. Thermostat**		
6. Condenser			Correct Temperature	❒	❒
Leakage	❒	❒	**20. Coolant**		
Mounting	❒	❒	Cleanliness/pH	❒	❒
Cleanliness	❒	❒	Test Results/Freeze Protection	❒	❒
7. Receiver Drier/Accumulator			**21. Heater Hoses and Clamps**	❒	❒
Mounting	❒	❒	**22. Heater Control Valve**	❒	❒
Fittings/Connections	❒	❒	**23. Evaporator**		
8. A/C Hoses and Lines			Leakage	❒	❒
Leaks	❒	❒	Connections/Fittings	❒	❒
Fittings/Connections	❒	❒	Condensate Drain	❒	❒
Rub Through	❒	❒	Odor	❒	❒
Mounting	❒	❒	**24. Panel Outlet Temperature**	❒	❒
9. Service Port Caps	❒	❒	**25. Dash Controls/Switches**		
10. Expansion Valve			Proper Air Routing	❒	❒
Leaks	❒	❒	Cable Operation	❒	❒
Sensing Bulb	❒	❒	**26. Blower Motor Operation**	❒	❒
Insulation	❒	❒	**27. A/C/Blower/Fan Relays**	❒	❒
11. Orifice Tube			**28. Underhood Switches/Controls/Sensors**		
Fittings	❒	❒	Broken	❒	❒
Leaks	❒	❒	Electrical Connections	❒	❒
12. Fan Shroud/Seals	❒	❒	Operation	❒	❒
13. Front Air Dam/Spoiler	❒	❒	Leakage	❒	❒

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NAME _____ TITLE _____

SHOP/CO. _____

ADDRESS _____

CITY _____ STATE _____ ZIP _____

COUNTRY _____

PHONE _____ FAX _____

E-MAIL ADDRESS _____ WEB SITE ADDRESS _____

Primary area of mobile air conditioning activity (check one):

- ☐ Service/Installation ($200 Annual Dues)
- ☐ Distribution ($400 Annual Dues)
- ☐ Manufacturer/Supplier ($700 Annual Dues)
- ☐ Educational/Training Facility ($140 Annual Dues)

(Note: Cannot be a shop owner, officer of an installer, distributor or manufacturing company.)

Automatic
***Monthly and quarterly rates available. Please contact the MACS office for details**

General description of your business:

_____

_____

Distributor for following brands (please list):

_____

_____

Percentage of business from A/C activities: _____%

Number of business locations operated: _____

☐ Enroll me as a MACS member.

_____
APPLICANT SIGNATURE

☐ Please send *MACS Service Reports* to me via email. _____
Email Address

Is there anyone else you can recommend who might benefit from MACS membership?

NAME _____ COMPANY NAME _____

ADDRESS _____ CITY _____ STATE _____ ZIP _____

PHONE _____ FAX _____

☐ Enclosed is my check for $ _____

☐ Please charge to (please check one) ☐ Mastercard ☐ Visa

CARD # _____ EXPIRATION _____

SIGNATURE _____ DATE _____

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Certification Training Manual:

Including: Refrigerant Recycling and Service Procedures for Mobile Air Conditioning Technicians and Best Service Practices

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